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VOLUME XV

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A LARGE AND MODERN ISOLATED POWER PLANT.

STEAM AND ELECTRICAL PLANT OF THE PRUDENTIAL BUILDINGS, NEWARK, N. J.

The largest, and withal the handsomest, office buildings in the City of Newark, New Jersey, is a group of five belonging to the Prudential Insurance Company of America. To supply light and power to these various buildings, there is an elaborate mechanical plant which for completeness and for the variety and character of its equipment possesses a number of features unusual in this class of work. It is situated in what is termed the "North" building, and being an exhibition plant, as well as a plant for general utility, not a little attention has been paid to improving its general appearance.

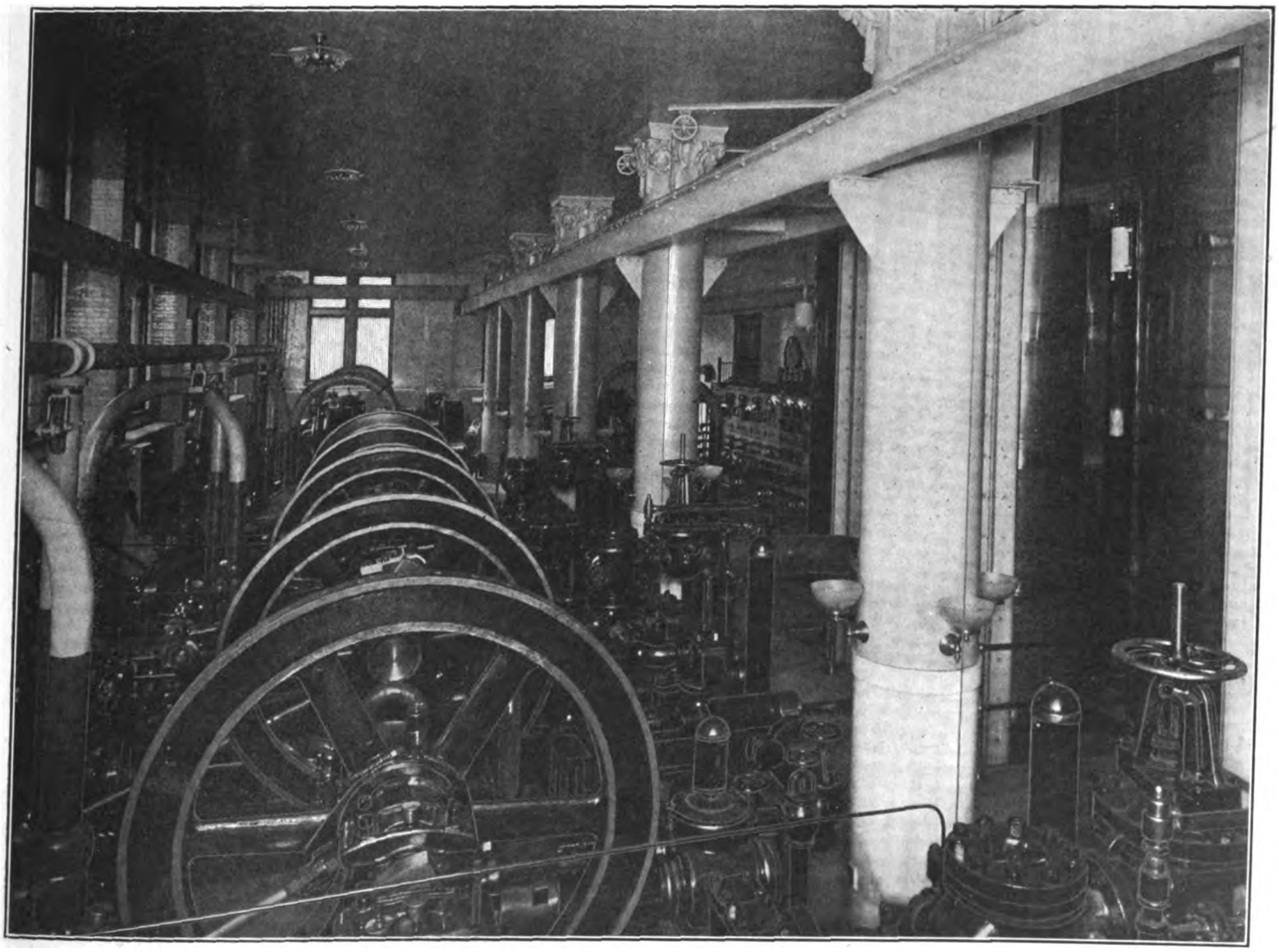

FIG. I.—GENERAL VIEW OF ENGINE ROOM IN THE NORTH BUILDING OF THE PRUDENTIAL INSURANCE COMPANY.

All of the five buildings are twelve-story structures and in the aggregate have above thirteen acres of floor space. The new mechanical plant supersedes that formerly serving in one of the older buildings, and power, heat and light are distributed to all of the buildings by means of tunnels under the separating streets. The mechanical plant supplies all of the lighting, heating, elevator service and a hot, cold and refrigerated water supply. Lighting is, as usual, by incandescent electric lamps of which there are almost 20,000 all told of 16 candle-power each on 110-volt circuits. The heating is largely by direct low-pressure steam radiation, supplied ordinarily with exhaust steam, and with live steam in case of necessity. The elevators are all of the hydraulic type supplied from the central plant with water at 800 pounds pressure. There are in the buildings twenty-seven passenger elevators, and, including the book-lifts and dumb waiters, thirty-six elevator units connected to this system. The plant occupies all of what might be termed the ground floor of the "North" building, except the space required for the main entrance hall and the elevators and stairways to the office floors above. It consists

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of an engine room which is in the building proper, a general view of which is given by Fig. 1, and a boiler house which is an addition on the rear side. The floor of the engine room is some distance below the street level, and as may be inferred from the illustration, the room is lofty, having high windows on two street sides, affording the public on the street a splendid view of all of the machinery. In order to make the plant serve for exhibition purposes, all of the piping as far as possible is carried in the cellar underneath the engine room floor, and the machinery is painted and polished a bright red color and striped in gold. The engine room contains four electric generating units, the pumping equipment and apparatus for the elevator installation, a number of other pumps, a feed water heater, and an elaborate switchboard facing the street windows. Vaults have been built underneath the sidewalks, and part of this space is utilized as a storage battery room. The engine room also contains two hand-power traveling cranes of 22-foot span, built by the Reading Crane & Hoist Works. The boiler room possesses many features which are unique, in so far as they relate to the power plant of an office building. It is provided with coal and ash handling machinery and a large overhead storage hopper or bin having a capacity of 750 tons, allowing coal to be conveyed to the fire space by gravity. Below the fire room floor there is a cellar containing boiler feed pumps, a number of tanks and the conveyors for hauling coal and ashes. In the boiler room there is also an elaborate ventilation plant and a refrigerating plant for furnishing iced water.

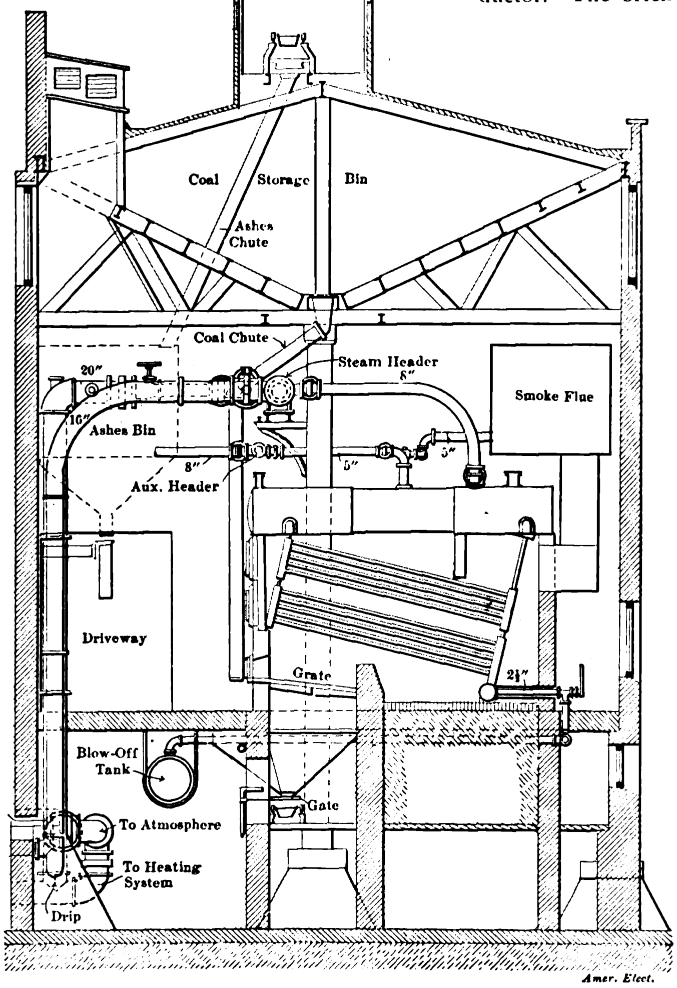


FIG. 2.—CROSS-SECTION OF BOILER HOUSE.

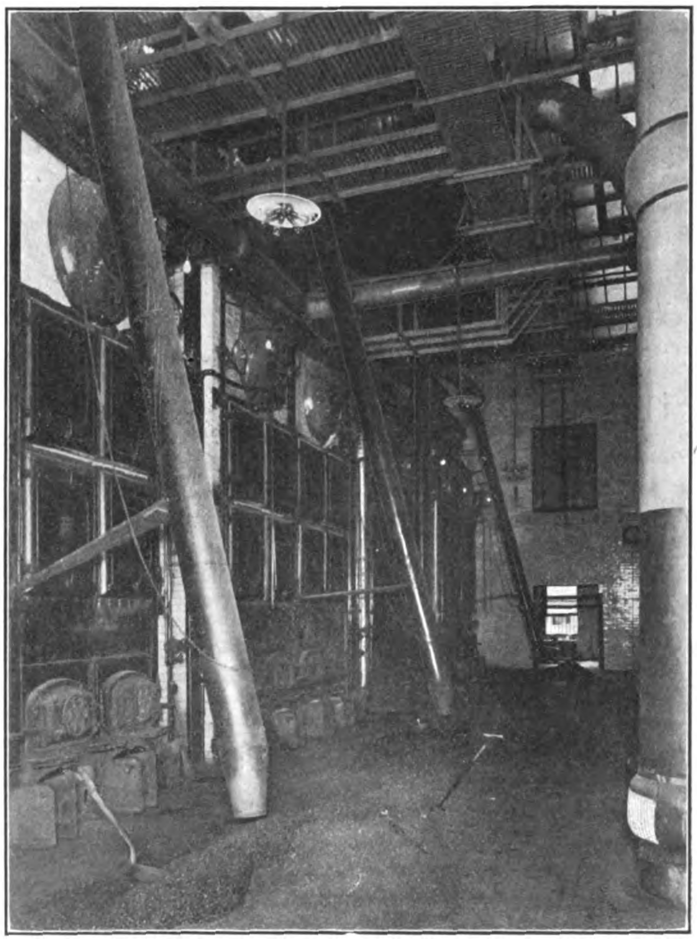


FIG. 3.—BOILER ROOM.

Steam for all purposes is supplied by four batteries of water-tube boilers, each containing two 250-h.p. Babcock & Wilcox boilers which generate steam at 150 pounds gauge pressure. These are of wrought steel construction and have the following dimensions: Each boiler contains nine sections of tubes, each section having twelve 4-in. tubes 18 feet long. The steam drums are 42 inches in diameter and 23 feet 4 inches long, and are made of ½-in. plate. Each boiler has 2217 sq. ft. of heating surface and 39.1 sq. ft. of grate surface, giving a ratio of 56.7 to 1.

The architectural conditions connected with the arrangement of the plant and exterior appearance of the buildings required that the chimney to serve the boiler plant should be built as an independent shaft carried to a height of 230 feet 9 inches above its foundations. Sectional views of this shaft are given by Fig. 4. Through the center of the concrete bed forming the foundation, a 4-in. terra-cotta pipe was imbedded in a vertical position to serve as a conduit for the copper lightning conductor. The brick base of the shaft is 19 feet square x 48 feet high, with an arched opening for the flue and boiler clean-out. The core wall is cylindrical with an inside diameter of 9 feet for the full height of the chimney. It is built of fire brick 18 inches thick and 48 feet high from the sill of the flue, and of hard red brick from this level to the top of the shaft. The stone shaft rises from a brick base which is an octagonal shell, having a batter of 1 to 55 with a diameter of 19 feet at the base and 13 feet at the top. It is built of dimension stone cut to specified sizes, the facing being of well-bonded Indiana lime stone, with a backing of cut granite. Eight corbels from the stone shell brace the brick core wall at intervals of 50 feet with just sufficient clearance to allow for contraction and expansion. Vent holes in the top of the stack permit the free circulation of air between the core wall and the exterior shell. The flue lining stops several inches from the bottom of the capital, space being allowed for expansion, and from this point the lining is built on the projecting stone of the capital, in this way counterbalancing the overhanging weight of the latter. As a protection from lightning, a copper cable ¼ inch in diameter extends from eight points at the top to a plate imbedded in charcoal beneath the foundation. The cable is secured to the shaft by copper anchors set at 10-foot intervals. The chimney is designed to carry off the gases of combustion from a battery of boilers aggregating 2,500 horse-power. Estimating an assumed evaporation of 7 pounds of water per pound of coal and 5 pounds of coal per horse-power per hour, the formula adopted for determining the area in square feet was: $A = 0.3 \times 2{,}500 \div \sqrt{188} = 54.71$. This gives the effective area in

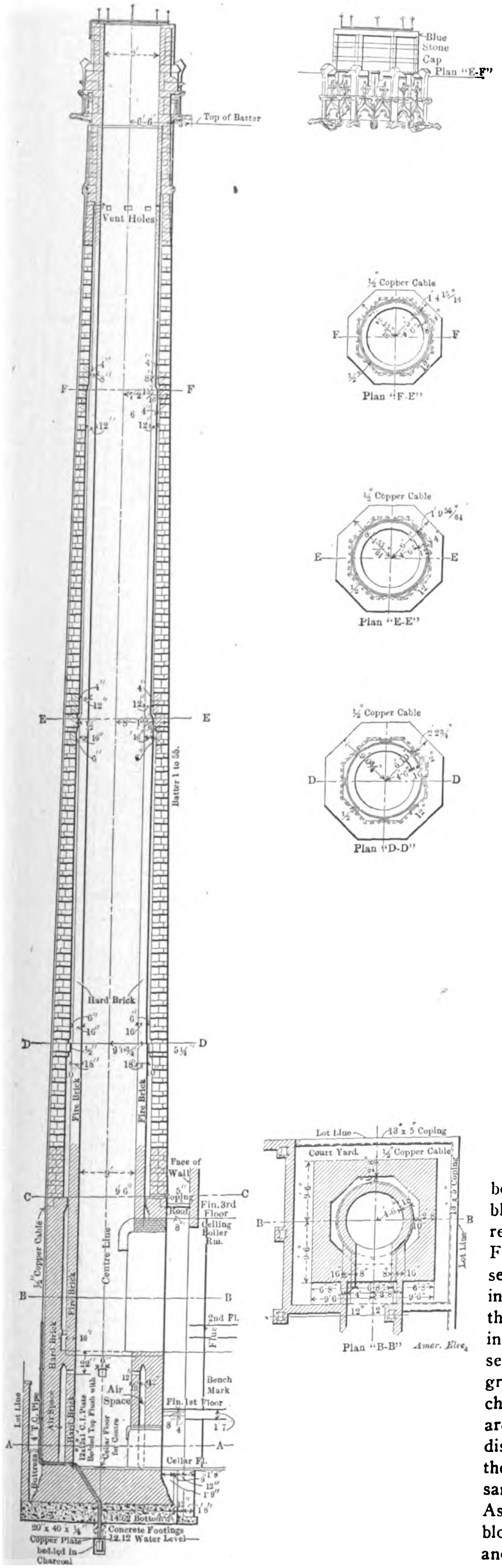
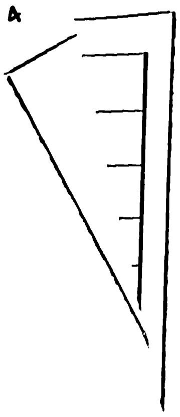

Blue Stone Cap
Plan "E-F"
Top of Batter
6'-6"
Vent Holes
½ Copper Cable
Plan "F-F"
Plan "E-E"
Plan "D-D"
F
E
D
C
B
A
Batter 1 to 55
Hard Brick
Fire Brick
Face of Wall
Coping
Fin. 3rd Floor
Roof
Ceiling Boiler Rm.
2nd Fl.
Flue
Bench Mark
Air Space
Centre Line
Fin. 1st Floor
Cellar Fl.
Lot Line
14'x2 Bottom
20' x 40 x ¼ Copper Plate bedded in Charcoal
Concrete Footings
12.12 Water Level
Lot Line
13" x 5" Coping
Court Yard
½ Copper Cable
Plan "B-B"
Amer. Elec.

FIG. 4.—SECTIONAL AND PLAN VIEWS OF CHIMNEY.

square feet equal to a diameter of 8 ft. 4 in. inside. Allowing for a cushion of air 4 in. thick over the whole interior surface to provide against the retardation of the velocity of the current by the friction of the walls, it is apparent that the actual diameter required is 9 ft., and this dimension is maintained throughout from the base to the capital. At the top the shaft is enriched with a capital of cut stone. This is carefully bonded and tied together vertically and horizontally with brass pipe dowels and dovetailed copper clamps in each course and surmounted with a cap course of blue stone. The smoke breeching connecting the boilers to the stack is of No. 8 black iron suspended across the rear of the boilers as shown by Fig. 7 and of the same cross-section throughout, changing in shape at the stack to enter the necessarily narrow and long inlet at that point. Its cross-section area is 25 per cent. greater than the full area of the chimney, and the aggregate area of the individual smoke discharges from the boilers to the breeching is practically the same as the main breeching. As a non-conducting covering, blocks of magnesia 1½ in. thick and fastened to wire mesh placed to enclose 2 in. of air space, were used with ½ in. of magnesia. plaster pair. coal and ash a belt conveyc veyor, the forn at the street and ing coal overhead also being used to dump them into an as are loaded by a spout coal is delivered througi sidewalk and falls into a This empties it upon a belt travels in the cellar of the nearest corner of the boiler The belt, which was furnished ster Manufacturing Company, is wide and is driven by a 2-foot pu. a 7½-h.p. C. & C. electric motor. is enclosed its entire length by a box 10 sheet metal in order to prevent the from flying about, and at the discharging end, after it dumps through a chute upon the bucket conveyor, it is cleaned by means of a wire brush which rotates against it. This conveyor hauls the coal upward at an angle of about 5½ degrees with the horizontal. The bucket conveyor is of the McCaslin type and travels in the usual way along the cellar floor underneath the ash hoppers, boilers and boiler ash pit, then up one end of the building and across overhead the length of the coal bin, and down at the other end of the building. It travels over a monitor to the roof above the bin, which affords sufficient light to inspect readily the distribution of coal throughout the hopper. At one end of the monitor is a 10-h.p. motor which drives the conveyor. The usual type of dump cart is provided, and at the opposite end of the monitor



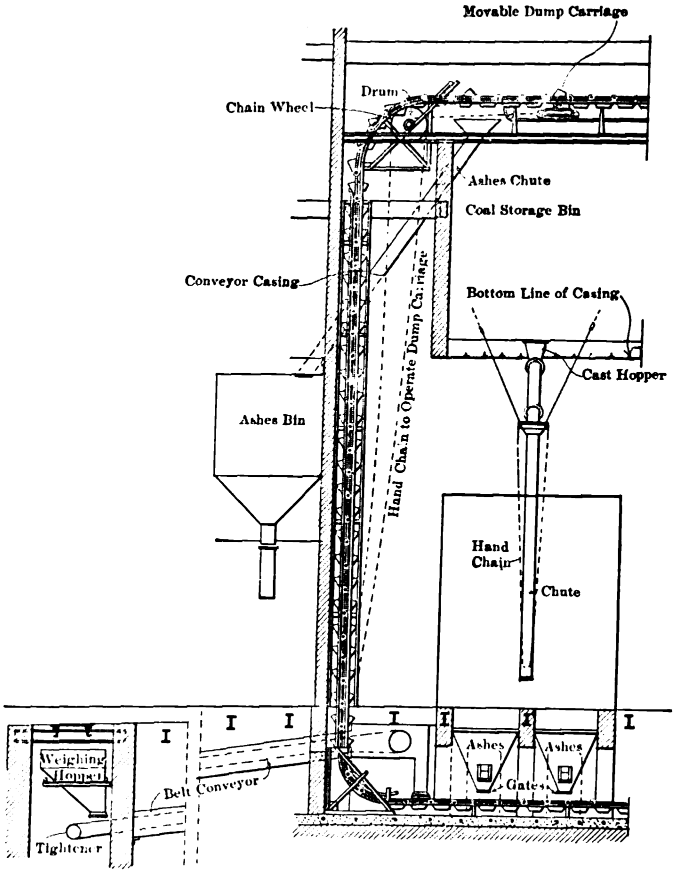

Movable Dump Carriage
Drum
Chain Wheel
Ashes Chute
Coal Storage Bin
Conveyor Casing
Bottom Line of Casing
Cast Hopper
Hand Chain to Operate Dump Carriage
Ashes Bin
Hand Chain
Chute
I
Weighing Hopper
Belt Conveyor
Tightener
Ashes
Ashes
Gates

FIG. 5.—CONVEYOR SYSTEM.

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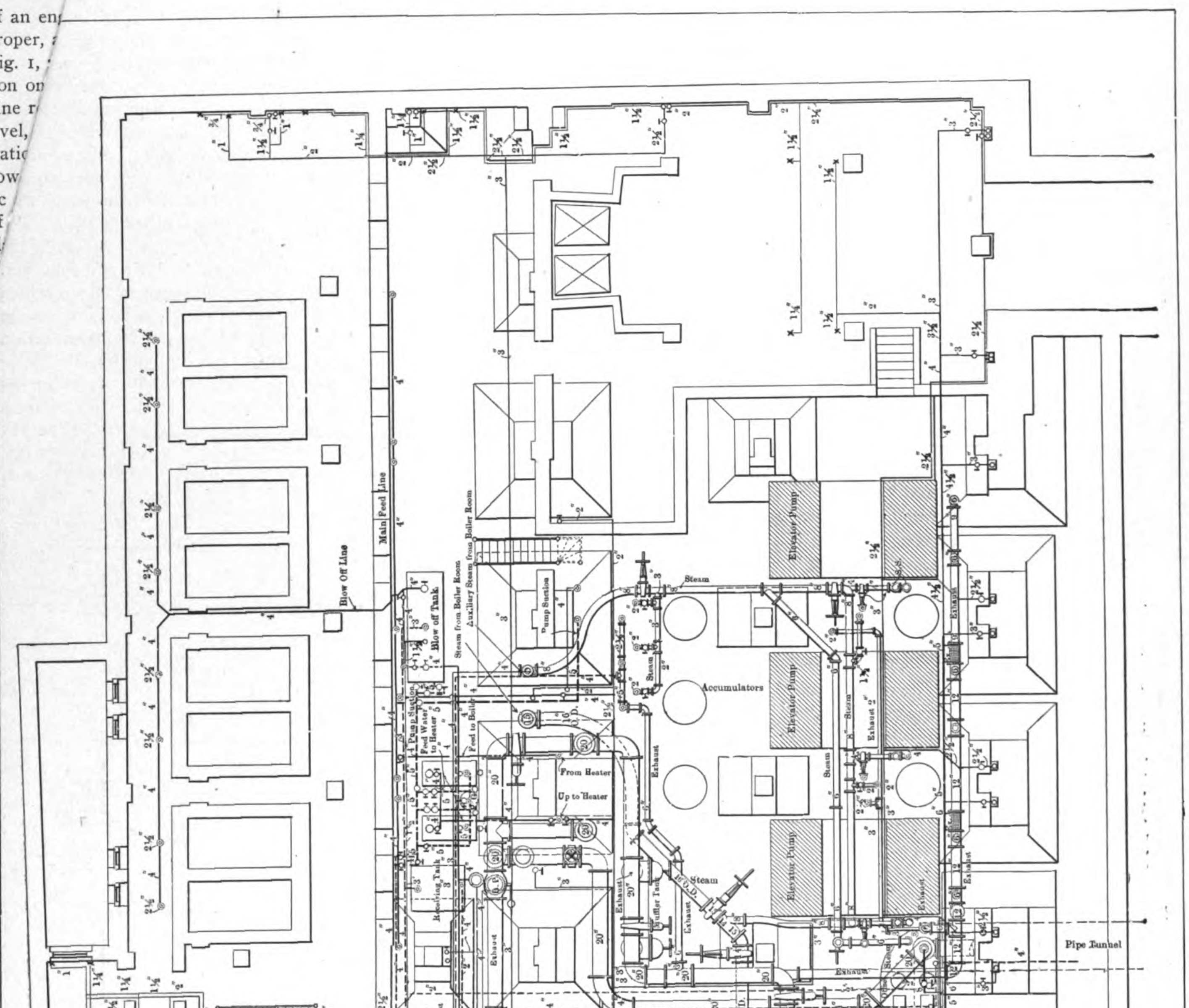
Main Feed Line
Blow Off Line
Blow off Tank
Steam from Boiler Room
Auxiliary Steam from Boiler Room
Pump Suction
Feed Water to Heater
Feed to Boiler
From Heater
Up to Heater
Receiving Tank
Steam
Accumulators
Elevator Pump
Elevator Pump
Elevator Pump
Exhaust
Buffer Tank
Pipe Tunnel
Electric Tunnel
Sewer
Engine
Engine
Engine
Engine
4 Overflow from Condenser to Icewater Plant
To be Trenched
Drain
Refrigerator Plant
Filter
Water Tank
Receiving Tank for Ice Water Plant. 5'x6'x6' high. To be placed on legs 7'0" abov Cellar Floor.
Amer. Elec.

FIG. 6.—DIAGRAM OF STEAM CONNECTIONS TO ENGINES, PUMPS AND AUXILIARIES.

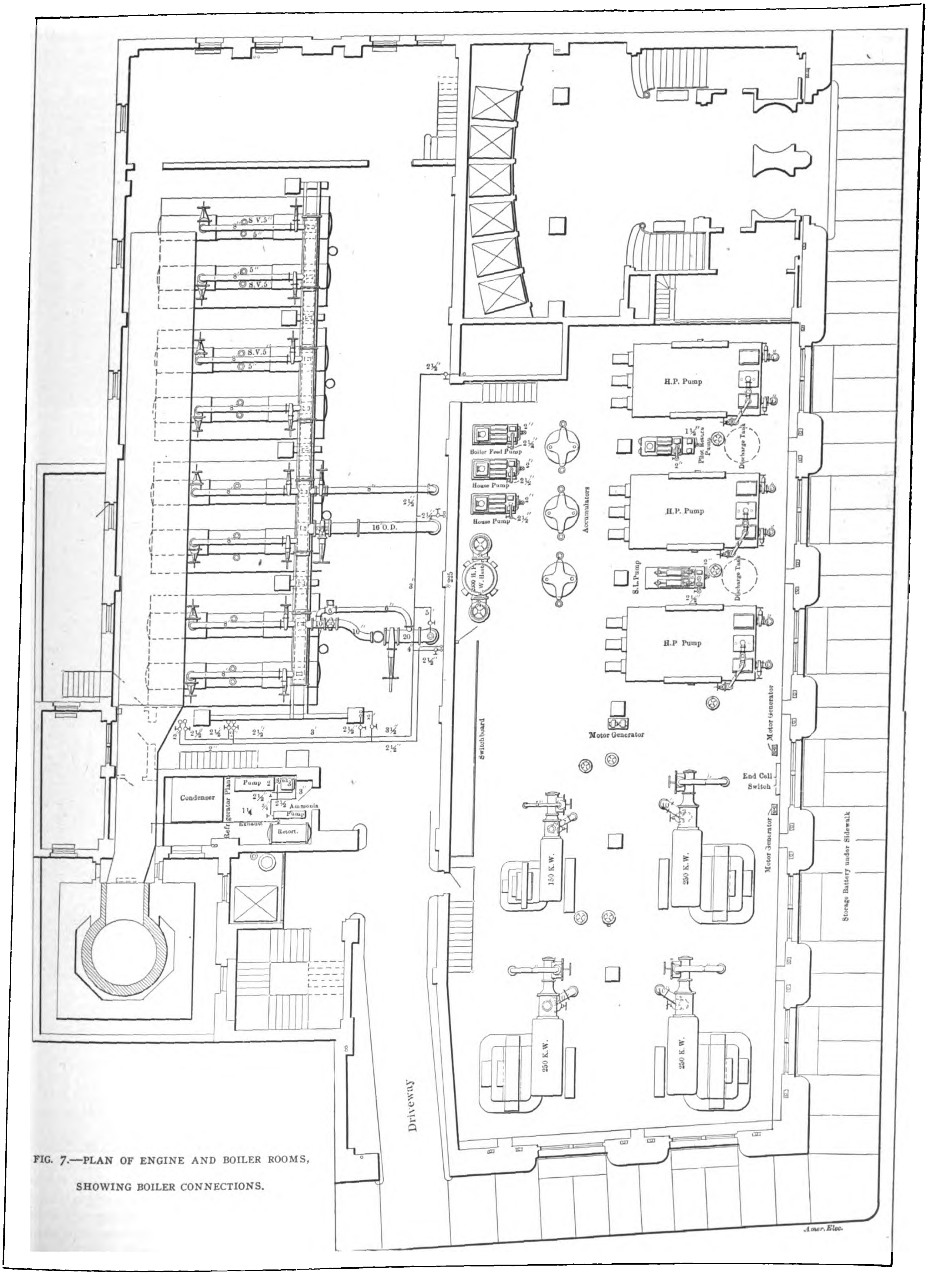
S.V.5″
5″
8″
16″O.D.
20
10″
2½″
3″
H.P. Pump
H.P. Pump
H.P Pump
Boiler Feed Pump
House Pump
House Pump
Accumulators
Pilot Return Pump
Discharge Tank
Discharge Tank
S.L.Pump
2500 H.P. W. Heater
225
Switchboard
Motor Generator
Motor Generator
Motor Generator
End Cell Switch
150 K.W.
250 K.W.
250 K.W.
250 K.W.
Storage Battery under Sidewalk
Condenser
Refrigerator Plant
Pump
Sink
Ammonia Pump
Exhaust
Retort.
Driveway
Amer. Elec.

FIG. 7.—PLAN OF ENGINE AND BOILER ROOMS, SHOWING BOILER CONNECTIONS.

from the driving motor is a chute through which the ashes are dumped from the conveyor to an ash hopper. The ash carts are backed in a driveway underneath this and there filled. The movable dump carriage can be controlled from the boiler room floor by chains. The coal bin is of the V-shaped class and its two sides, which are of brick arches sprung between longitudinal I-beams, are pitched about 23 degrees.

Steam is supplied by two headers each having independent connections from each of the boilers. The generating units are supplied by a 20-inch header, and an 8-inch header supplies steam to the various pumps. This latter header has a cross-connection with the larger header and is joined in the cellar under the engine room with a main from the larger header, so that the pumps for the elevator system can obtain steam from either source. The steam piping in the boiler room is shown by Figs. 2 and 7, while that in the basement of the engine room is shown by Fig. 6. An 8-inch pipe feeds the 20-inch header from each boiler with a valve both at the steam drum and at the header. From the header are taken a 16-inch main for the electric generating units, a 10-inch connection for supplying the heating system through pressure-reducing valves when live steam is necessary, and an 8-inch main joining the main header with the auxiliary or pump system of steam mains. For the auxiliary header, the safety valve outlet from each boiler is fitted with a Y-fitting, and to one branch of this is attached the safety valve and to the other a 5-inch connection of the auxiliary header. Two valves are also fitted in the auxiliary header feeders. All of the safety valves are provided with exhaust or discharge pipes and these all connect into a discharge main which is carried into the smoke breeching close to the smoke stack.

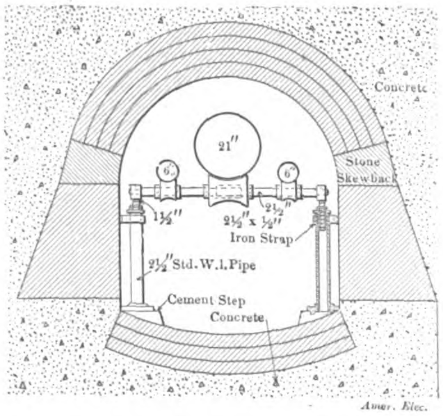

FIG. 9.—PIPE TUNNEL.

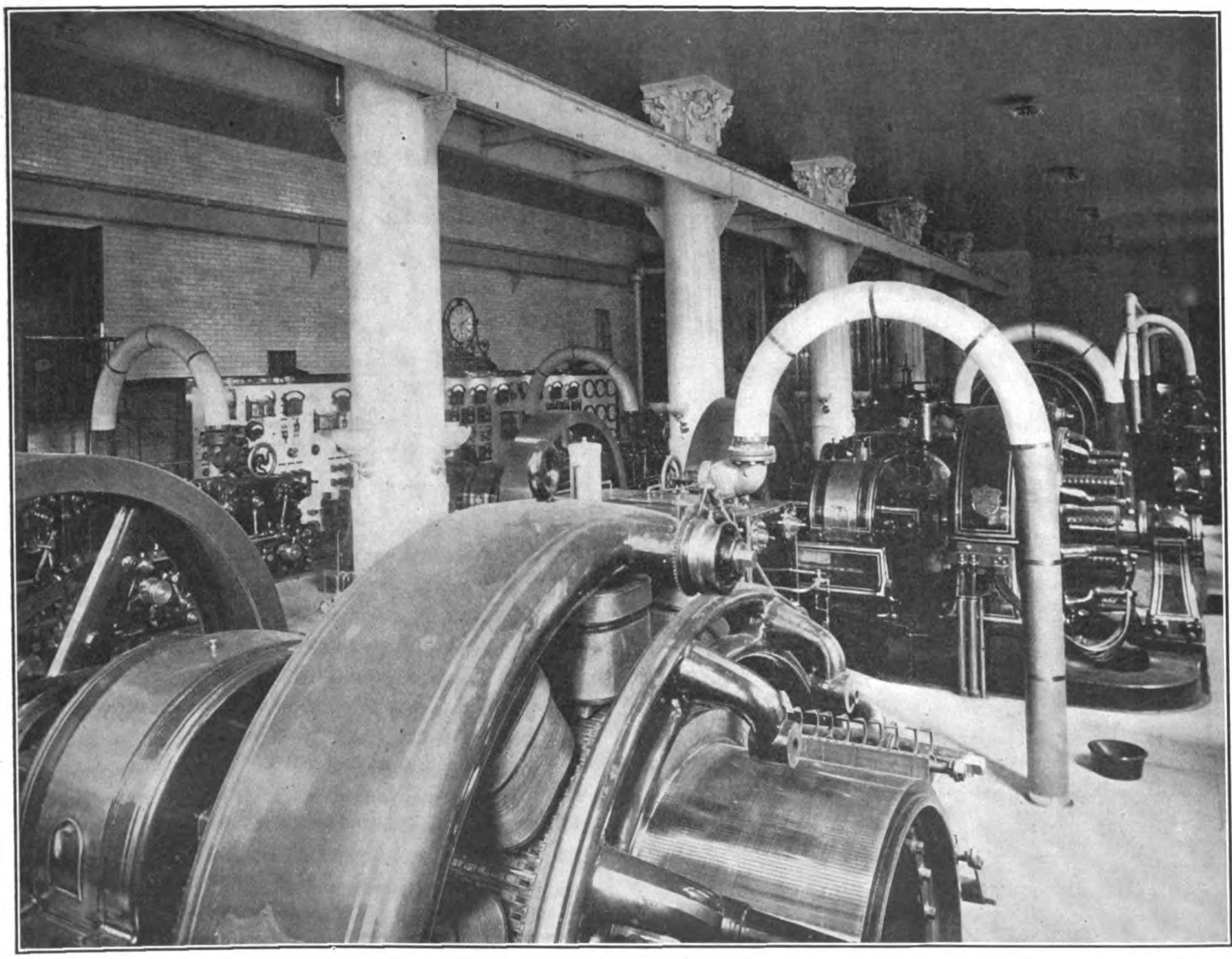

FIG. 8.—VIEW OF ENGINE ROOM, SHOWING GENERATORS.

The working steam pressure is 150 pounds per square inch, and the steam piping was tested to stand a hydrostatic pressure of 250 pounds. The pipe bends from boilers to headers, the high-pressure mains from the headers, and the branch pipes to the engines and pumps are all of wrought iron with valves and fittings designed according to the Walworth Manufacturing Company standard for 250 pounds pressure. The flanges have a plain face with a raised surface for gaskets and are spot faced for bolts. For high-pressure pipes 6 inches and larger, the Van Stone joint is used and also for low-pressure work having pipes 7 inches in diameter and over. On the other high-pressure pipes extra heavy screwed joints are used with the pipe flush with the flange after the latter was faced off in a lathe. The gaskets are of corrugated copper. The steam headers are made up of cast gun iron with which the connections to and from the headers are made, and of steel pipes with the Van Stone joint, the gun iron headers being opposite each pair of boilers and the steel pipes connecting the gun iron parts. The gun iron headers are built with heavy ribs made of iron having a tensile strength of 30,000 pounds and with flanges drilled for the Walworth

250-pound standard. The make-up of the steam header is shown by Fig. 11. The headers are supported from heavy brackets, the 20-inch header being on roller chairs to allow for any movement owing to expansion.

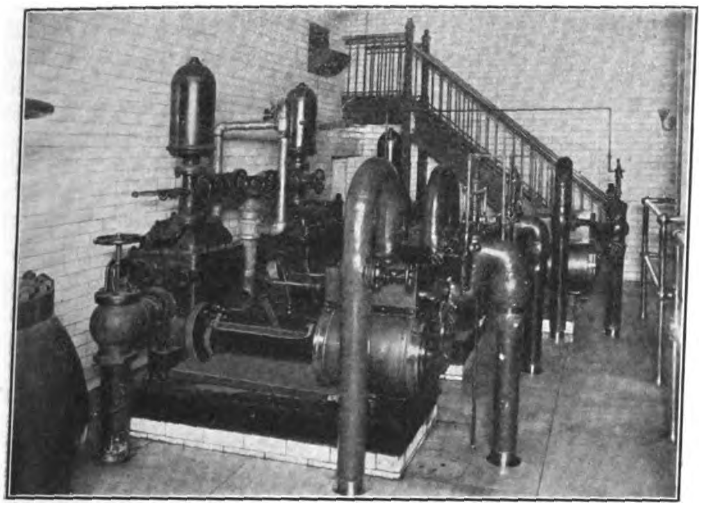

FIG. 10.—HOUSE AND FEED-WATER PUMPS.

The machinery in the engine room is in general supplied by wrought iron bends rising through the floor and turning downward to the steam cylinders, as shown by Fig. 8. These are of sufficient length to eliminate flanged joints between the throttle and the elbows below the floor. The 16-inch (outside diameter) pipe in the boiler room is dropped from the main header to the cellar, as shown by Fig. 2, and subdivides into a 15-inch (outside diameter) main for the electric generating units, and into an 8-inch pipe which connects to a pipe of similar size carried from the auxiliary header into the cellar. At this cross-connection are tapped the steam supply pipes to the elevator pumps. The steam connections to all of the engines and to the main elevator pumps are provided with De Rycke steam separators in the cellar and in addition to the throttle valve, have bevel geared valves near the supply mains in the cellar and operated from floor stands in the engine room. The entire piping was installed by Baker, Smith & Company, of New York City.

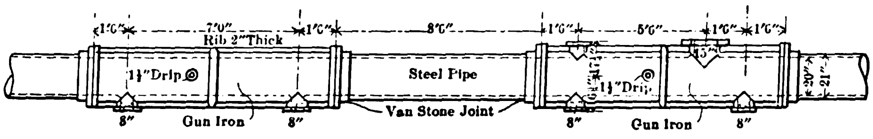

FIG. 11.—DETAILS OF STEAM HEADER.

The elevator equipment includes three compound 3-cylinder Laidlaw-Dunn-Gordon pumps, the three cylinders being located side by side and driving three water plungers, a safe-lifting pump and two pilot return pumps. The large pumps have one 17-inch steam cylinder and two 19-inch steam cylinders, 5-inch water plungers and a common stroke of 24 inches. For regular service a pressure of 800 pounds is maintained by the pumps, with perhaps an average of 720 pounds at the elevators, so that the volume of water necessary is less than with a lower pressure, and consequently smaller pipes to the different buildings are possible. With this high pressure, instead of the pressure tank usual with lower pressure systems, accumulators are used. These consist of weighted tanks which rise through the cellar into the engine room. For the satisfactory operation of the valves to the elevator cylinders, a low-pressure hydraulic system has been installed, for which purpose the pilot return pumps have been provided, maintaining a pressure of 80 pounds. The elevator equipment is shown in the foreground of Fig. 1. Between the three accumulators and the partition wall are three 10x6x10-in. Laidlaw-Dunn-Gordon duplex pumps, two for house and fire service, and the third with outside packed plunger for boiler feeding. These pumps are shown by Fig. 10. A 2,000-h.p. Berryman feed water heater is also located in the engine room; it is 58 inches in diameter and has a height of 17 feet.

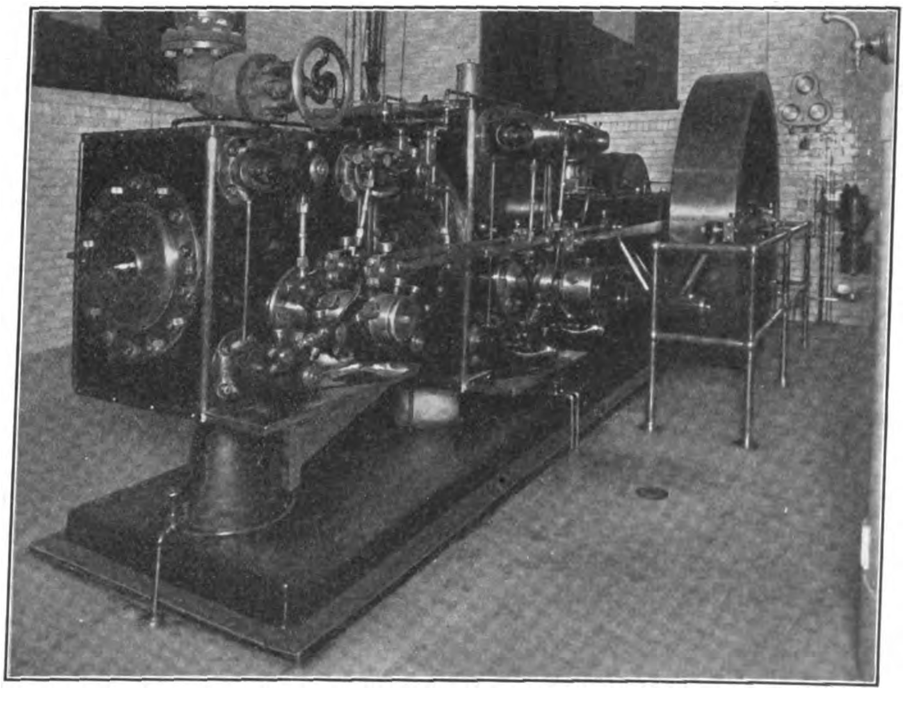

FIG. 12.—VIEW OF ONE OF THE LARGER ENGINES.

The electric generating units are located at one end of the engine room and consist of four Bullock generators direct-connected to Ball & Wood non-condensing tandem compound high-speed Corliss valve engines, three of these being of 250-kw. capacity and one of 150-kw. capacity, and all generating current at an e.m.f. of 120 volts. Three of the engines have cylinder dimensions of 17 and 30 inches with an 18-inch stroke, and the smaller engine has cylinder dimensions of 20 and 22 inches with a 16-inch stroke. A view from the generator end of the engine room is shown by Fig. 8.

The exhaust steam from the engines is collected into an 18-inch main, while that from the elevator pumps is collected into a 12-inch main, and the two units into a 20-inch main, as shown in the piping plan illustrated by Fig. 6. To provide for expansion in these lines, Wainwright expansion joints are employed. The exhaust first passes through a tank 12 feet long and 4 feet in diameter, which is a Utility combined grease extractor and muffler tank. It is constructed of ⅜-inch steel with ½-inch heads and is provided with a by-pass. The exhaust main then connects with the feed-water heater, about which it has a by-pass in the cellar. From this point the steam may pass into the heating system or into the atmosphere through the usual back-pressure valve. Here as shown, is the auxiliary live steam supply to the heating system. This is a 20-inch pipe dropping from the boiler room, starting as a 10-inch pipe from the main steam header and fitted with two Kieley reducing valves arranged in series to reduce the steam pressure from 150 pounds to 80 pounds and from 80 pounds to zero. The heating main continues 20 inches in diameter through the cellar to the tunnel to the West building, supplying on the way a 10-inch main for the North building and the Northwest building. A section of the tunnel connecting the West and North buildings is shown by Fig. 9. The tunnel is built in duplicate, that is, two tunnels are parallel to each other about 6 or 7 feet apart and unite at each end. One is given up to steam and other piping as indicated, and the other to electric cables and wires. The tunnels are each 75 feet long and their floors are about 21 feet below the street level. The steam pipes are supported as shown on wrought iron pipe stands adjustable as to height; besides the heating main, there is a high-pressure main and a corresponding exhaust main. The heating main is graded slightly in the direction of steam flow, and at convenient points, suitable drain connections are provided. To receive the drip water from the piping in the cellar and the tunnel, 18-inch tanks 5 feet long are located at the power plant end of the tunnel, one to collect the high-pressure drips, another the low-pressure drips, and a third the drips from the plumbing system; each tank is served by a small duplex steam pump under the control of the pump governor, one delivering the high-pressure drips to the main receiving tank, while the low-pressure drips, containing grease-laden water from the exhaust mains, is discharged into the blow-off tank. The heating return main is 4 inches in diameter and passes through the cellar of the plant to the main receiving tank which is located against the boiler room cellar wall. All the condensation from the heating systems of the buildings is returned to the main receiving tank and supplemented as may be necessary by water from the receiving tank of the refrigerating plant. Near the main tank are two feed-water pumps of the same size and type as the feed-water pump in the engine room, the latter pump being a reserve which is connected up for house and fire service as well. The pumps discharge through a feed-water filter, and the Berryman feed-water heater before delivering to the boilers. The filter is a Ward combination zinc box and filter composed of 10 cast iron 18-inch cylinders 7 feet high.

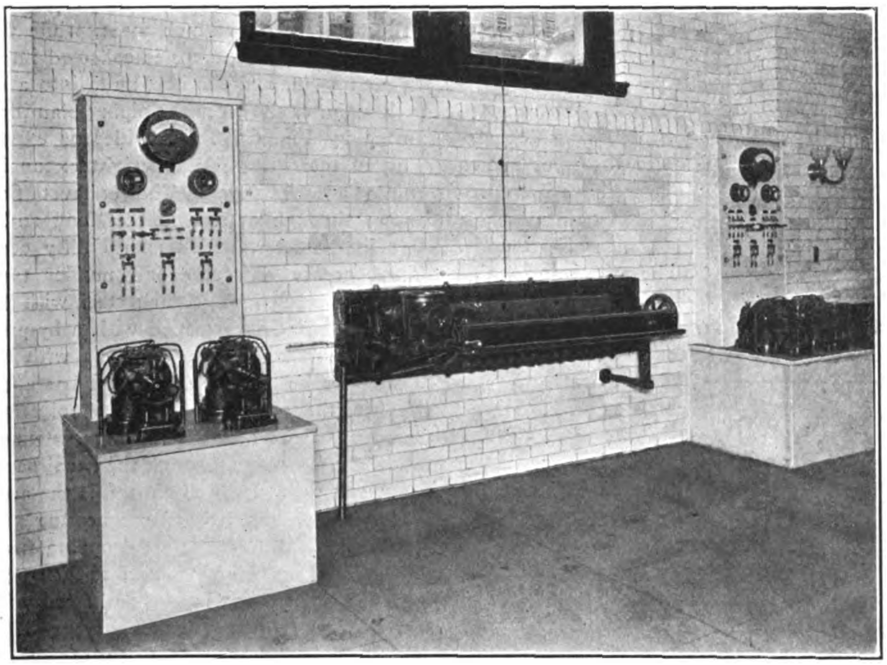

FIG. 13.—END-CELL SWITCH AND MOTOR-GENERATORS FOR ANNUNCIATOR SYSTEM.

All the feed piping is of brass 4 inches in diameter, and the main extends under the boiler room floor with 1½-inch brass connections rising through the floor to the boilers. Each riser has a 1½-inch inlet for and flanges, etc., of the feed piping are of an injector connection; the valves, fittings cast bronze. The blow-off tank, located as shown in Fig. 2, is 4 feet in diameter and 12 feet long. Its contents have to be cooled before they are discharged into the sewer, and such fresh water as may be required for the plant is passed as usual through a submerged coil within the tank. There are 10 of these made of 2-inch seamless brass, with their ends connected to two cast-bronze headers with 5-inch water connections. An elaborate system of ventilation is provided which calls for a 15-h.p. C. & C. motor to drive the Sturtevant centrifugal blast wheel, and a 20-h.p. motor to drive a Sturtevant centrifugal fan for exhausting the vitiated air into the atmosphere.

An automatic oiling system supplies lubricant to every bearing and moving part requiring it. This system is operated by compressed air which forces the oil from a tank to the bearings. In the oil room are located a return tank, a pump to pump waste oil from the tank to the filters, two oil filters, a pump to pump refined oil from the filters to the pressure tank, a pressure oil tank, an air pump and the floats and regulators necessary to make the system entirely automatic. The return tank is equipped with a float which automatically operates the pump when the oil rises above a certain height. The compressed air oil tank is also equipped with a float to automatically keep the oil at about the same level. To pump the oil from the return tank into the top of the filter and from the bottom of the filter into the compressed air oil tank, two direct-connected, motor-driven Quimby screw pumps are installed which may be stopped and started automatically by the floats in the tank. To keep a constant air pressure in the oil tank, in order to force it to the bearings, there is a small direct-connected, motor-driven air pump operated by a pressure regulator connected to the tank. The two oil pumps are so piped as to be interchangeable, and the suctions of both are fitted with valves and necessary connections and hose so that they may be used to pump out oil barrels, tanks, etc. The filters are in duplicate and of Turner make, fitted with steam and drip connections. The electrical connections to the pump motors are so arranged that they may be operated independent of the floats and regulators if necessary.

The oil supply is carried under the floor of the dynamo room in iron pipes and run up through the floor where necessary. At each oiling point there is a sight-feed oiling device with valve, which may also be operated manually. Above the floor the oil is carried in polished brass pipe. The waste oil is carried to the tank by gravity. In two points in the dynamo and engine room are two oil outlets and drip-pans to draw oil into cans. These are connected to the oiling system, the supply and waste pipes being hidden.

The storage battery shown by Fig. 14 is located in a vault under the sidewalk and is used for night service when few lights are needed, or as a reserve in case of breakdown. It has a capacity of 800 ampere-hours and includes 15 end cells, which are controlled from the switchboard through the medium of a motor-driven, end-cell switch. This switch is shown in Fig. 13. A Crocker-Wheeler motor-generator situated in the engine room is used as a booster to charge the batteries. The vault which contains the storage battery has a fan-motor exhaust to the atmosphere, lead lined to resist the action of the acid fumes.

The switchboard shown by Fig. 15 is of white Italian marble 7½ feet high by 36 feet long and divided into 9 panels; one panel is used for the storage battery, four panels for the generators, three panels for the various feeders, and one panel for the steam and pressure gauges. On this latter panel are eight steam gauges corresponding to the eight boilers, a low-pressure steam

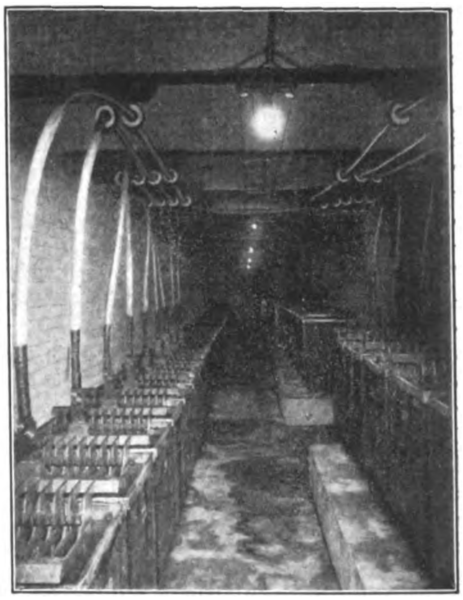

FIG. 14.—STORAGE BATTERY.

gauge, a vacuum gauge and a recording steam gauge. The switchboard is 2 inches thick. It stands 5 feet from the wall and is polished on both sides. It is supported on pedestals, and the ends are enclosed in electro-bronze iron screen work with doors at each end. The front of the board is surrounded by a plain 4-inch copper moulding. All of the circuits, switches and instruments are marked with engraved copper plates, having filled black enamel letters. All circuits not provided with circuit breakers have fuse blocks on the switches. The instruments are of the Weston illuminated dial type, having a copper finish. The ammeters are mounted directly on the board, the voltmeters being on swinging brackets to enable their being seen from any part of the room. The generator section contains four rheostats, three ammeters, and shunts for 2,500 amperes, one ammeter and shunt for 1,500 amperes, two 125-volt voltmeters, each with a circular switch properly marked to connect it to all of the dynamos, potential wires, bus-bars and battery; one of the voltmeters being calibrated in ohms to act as a ground detector. There is also a 125-volt voltmeter connected so as to be thrown onto the dynamos, battery, etc., and also onto either bus-bar. Four automatic circuit-breakers, having a capacity of 2,000 amperes each, four 2,000-ampere, double-pole, double-throw knife switches, four 2,000-ampere, single-pole equalizing switches, and six small double-pole knife switches, complete the equipment of the generator section. The feeder section contains a double-pole automatic circuit-breaker having a capacity of 2,000 amperes for power for the Northwest building, a double-pole automatic circuit-breaker of 2,000-ampere capacity for lights in the Main building addition, one double-pole circuit-breaker having a capacity of 1,000 amperes for lights in the North building, one double-pole, automatic circuit-breaker of 1,000 amperes capacity for lights in the West building, a similar circuit-breaker for lights in the Northwest building, and two circuit-breakers for future extensions. Besides these, there are 12 circuit-breakers for various circuits in the North building. There are also 12 double-pole, single-throw knife switches for lights in the dynamo room, two double-pole, single-throw knife switches for the ammeters on the feeder section, one 2,000-ampere, double-pole, double-throw knife switch for connecting the two busses together, five ammeters for measuring the current of as many buildings, a spare ammeter, a 125-volt Bristol recording voltmeter, a General Electric wattmeter having a capacity of 5,000 amperes and connected to the bus-bars to measure the total output for lights, a similar wattmeter having a capacity of 2,000 amperes for measuring the total power. The storage battery section contains a voltmeter registering from zero to 175 volts and provided with a circular switch to connect it to the charging and discharging circuits and to the busses, booster and potential wires; an ammeter registering 200 amperes to the right of zero and 200 amperes to the left of zero; a Weston portable voltmeter registering from zero to 3 volts and provided with a circular switch to connect it to the end-cell connections to the battery; a General Electric, double-dial, reversible wattmeter; an automatic underload switch; a rheostat for the booster field; an automatic starting box for the booster motor, a single-pole, automatic circuit-breaker; an 800-ampere double-pole automatic circuit-breaker; four double-pole switches; a combined switch and push-button connected so as to operate the end-cell switch; and an indicator, electrically oper-

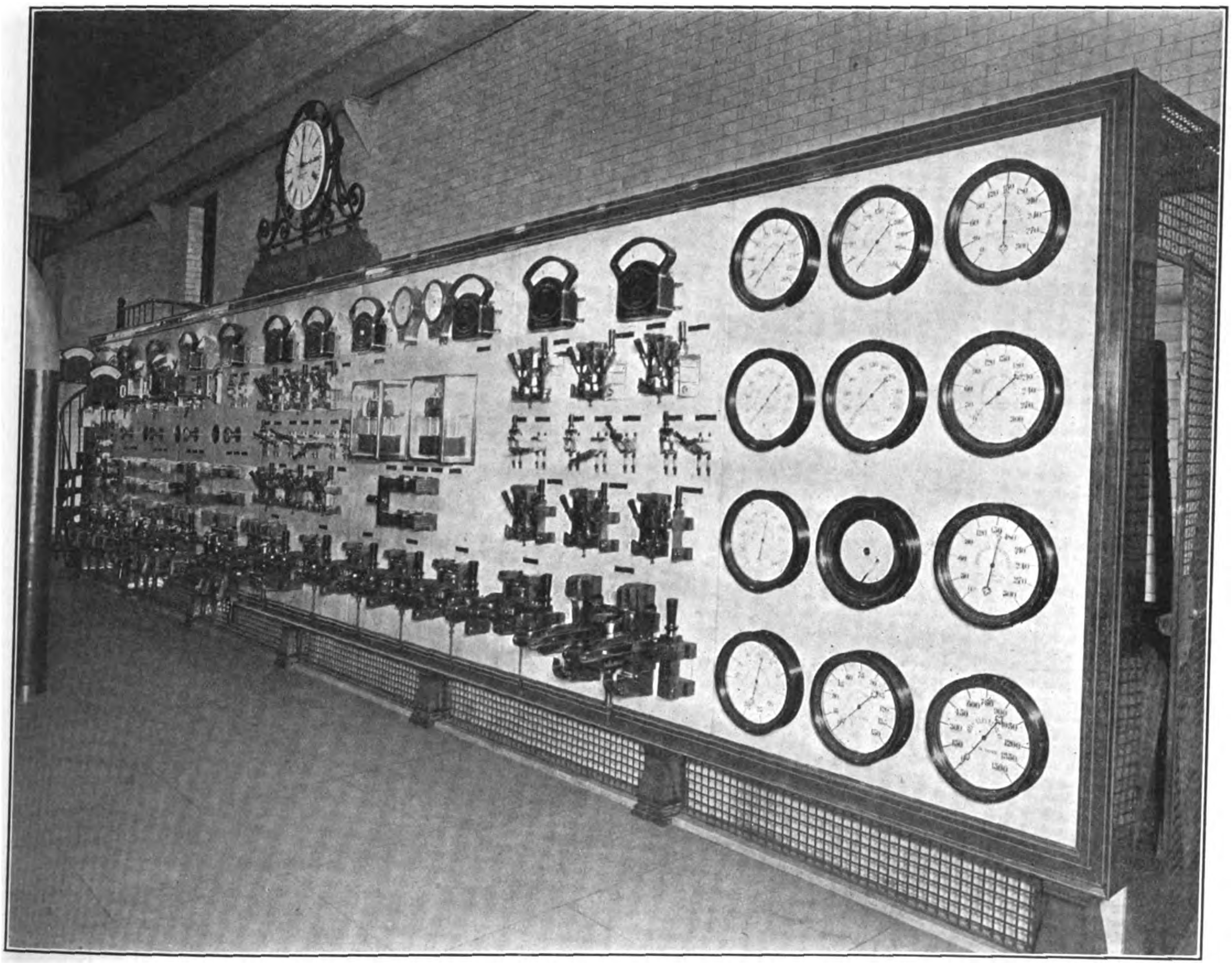

FIG. 15.—MAIN SWITCHBOARD, PRUDENTIAL COMPANY'S POWER PLANT.

ated, which shows the position of the end-cell switch.

The general scheme of wiring is as follows: There are two busses, one for light and one for power; the dynamos and storage battery can be connected through double-pole, double-throw switches to either bus. The lighting circuits can only be connected to the lighting bus, and the power circuits to the power bus. The busses can, however, be thrown together by means of a double-pole, double-throw switch, so that either bus can be connected to the other without throwing it out of service. Wattmeters record the total amount of current used in either class of service. The battery section connects to the main busses by means of copper bars and has both power and light busses, so that it can be charged or discharged from either bus. Each building, except the North building, in which the plant is located and feeders brought to the main switchboard, is supplied by a service feeder controlled by a double-pole circuit-breaker and single-pole knife switch, the various feeders of the North building being similarly controlled. The service feeders are paper-insulated, lead-covered cables installed in conduits running through tunnels under the street and imbedded in the cellar floors in the buildings. Manholes are provided for installing the cables. In each of the four buildings thus supplied, there is a secondary marble switchboard with double-throw switches, enabling the building feeders to be connected to the plant or to the street service, the latter precaution providing for a total breakdown of the plant. The feeding system of each building is the usual feeder and main system, with cut-outs on each floor supplying the branch circuits, the halls being supplied by separate feeders. The Northwest building is supplied by two feeders, one for light and one for power. In this building the Prudential Insurance Company operates an elaborate printing establishment, which furnishes all the printing required by the company. The printing department has 22 motors, the greater portion of which are direct-connected to printing presses; these are Bullock machines controlled by Cutler-Hammer starting boxes and vary in size from 1 to 25 horse-power. Figs. 16 and 17 show corners of two of the press rooms. Fig. 18 shows the motor which supplies the power for the bindery; this is a belted machine, driving a line of concealed shafting to which the various cutters and binders are connected. The company has an elaborate electric bell installation which is supplied from the small motor-generators shown in Fig. 13, and also elaborate telephone and clock systems which will be described in a subsequent article. In the tower of the North building is a huge tank having a capacity of 18,000 gallons, from which all of the water required in the buildings is taken. This tower is illuminated by 600 lights.

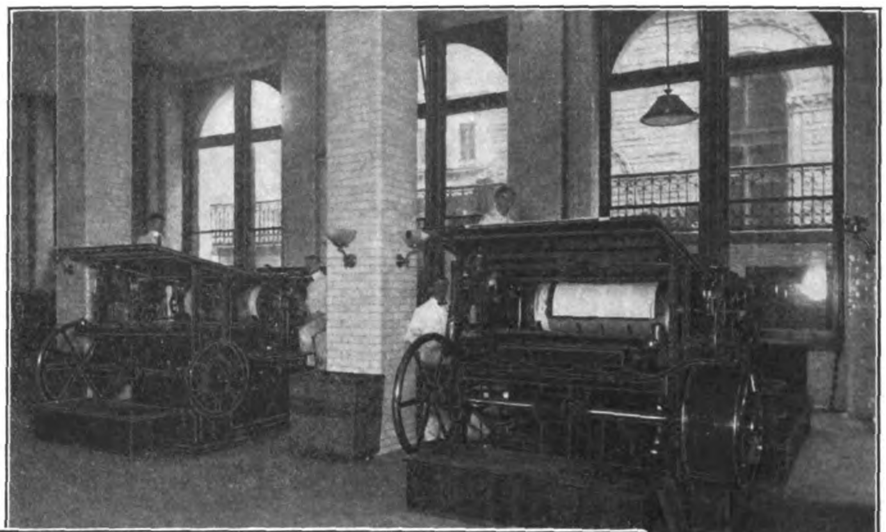

FIG. 16.—PRESS ROOM.

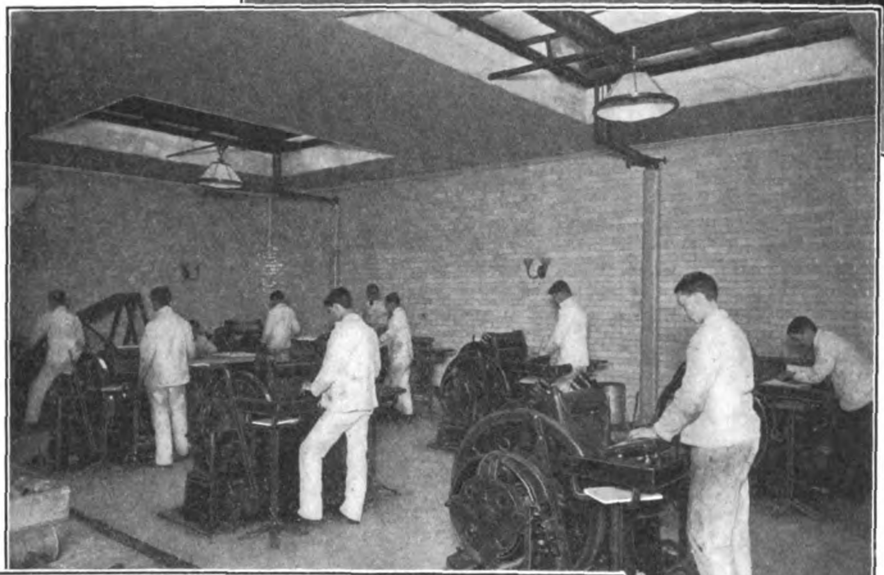

FIG. 17.—PRESS ROOM.

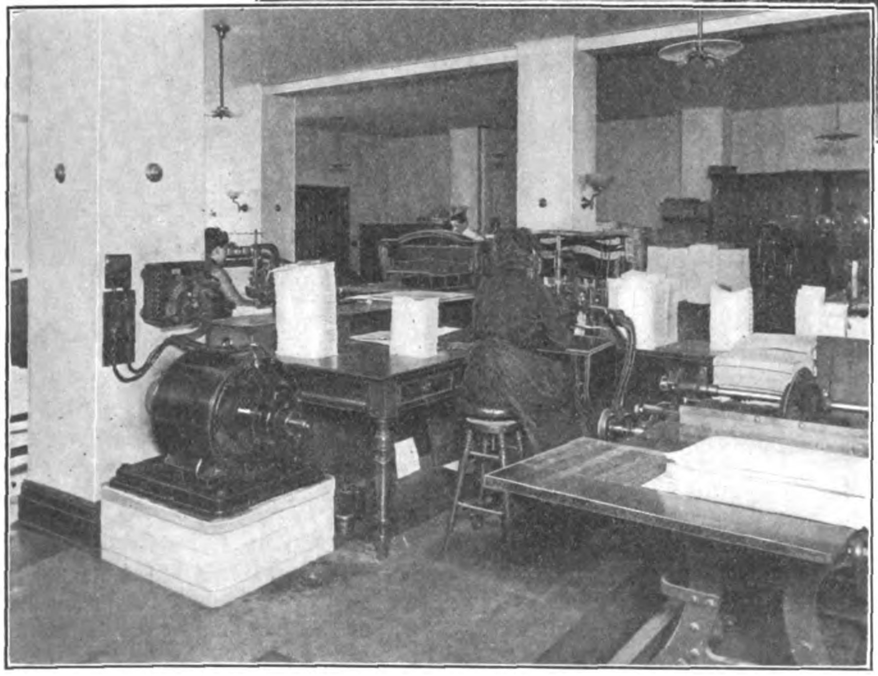

FIG. 18.—VIEW IN BINDERY, SHOWING MOTOR.

The entire electric equipment was installed under the supervision of Pattison Brothers, consulting engineers of New York City, Hatzel & Buehler, of New York, being the electrical contractors. There are in the various buildings seventy electric motors of Bullock, Sprague and C. & C. make, whose sizes vary from 1 to 50 horse-power. Each motor has a Weston shunt attached to it, so that current readings may be easily taken.

The switchboard was installed by the General Incandescent Arc Light Company, of New York. The architect for the buildings was George B. Post, of New York. We wish to record our indebtedness to Mr. Tysilio Thomas, the able head of the real estate department, for valuable assistance rendered in the preparation of this article, and also to F. A. Heimbold, electrical engineer of the company, for courtesies extended.

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SUPERHEATED STEAM.

BY E. H. FOSTER.

While in the march of progress we have been gradually raising steam pressures, we have kept pace with the corresponding increase of temperature by improvements in construction until we have already removed the barriers and paved the way for the introduction of superheated steam.

While it is difficult to form an exact estimate, there have probably been as many as 7,000, and possibly more, superheaters successfully installed by European manufacturers during the past ten or fifteen years, and the fact that the number of installations is rapidly increasing is the best proof that they are on the right track.

For a wide range beyond the temperature and corresponding pressure at which it is formed, steam possesses all the properties of a perfect gas, and therein lies one of its chief values as a vehicle for carrying heat into an engine to be transformed into power. Steam is so generally used in an engine because of its high latent heat, which allows the loss of a considerable amount of heat before condensation begins. But without superheating we stop at the threshold, whereas we might easily continue on to a place of safety, and instead of passing the steam through the engine on the ragged edge of condensation, it is easily within our reach to fix the gas permanently by raising it in temperature and adding enough heat units to supply the demands, both useful and wasteful, while it is passing through the engine.

Much of the indifference to superheated steam has been due to the unreliability of the superheater, which has not always been of proper design; but at the present time there is no difficulty in obtaining a suitable and efficient apparatus at a reasonable cost. There are several good makes on the market, each possessing advantages of its own.

The general method of superheating steam is to take the saturated steam from a boiler drum and pass it through coils surrounded by heated gas. The coils may be placed within the boiler setting so as to intercept the gases from the boiler furnace in their passage through the boiler, or they may be placed in a setting independent of the boiler and supplied with heat by a furnace of their own, or they may be set outside of the boiler and supplied with heat by drawing a portion of the gases from the boiler furnace, passing it through the superheater and returning it to the boiler or economizer.

The coils are made of seamless drawn steel tubing or of cast iron of a suitable composition to stand high temperatures, important advantages being claimed for each. Whatever the method of construction adopted, the material used must be of the very best and the joints and connections made in the most approved manner, and with the greatest care. With such precautions as are now considered good practice, the superheater may be depended upon as safely as the boiler, or engine, or any other part of the plant.

In considering the advantages and disadvantages of superheating with regard to engine work, take cognizance of the four distinct conditions under which steam is used, namely, saturated, superdried, moderately superheated, and highly superheated.

Saturated steam may be taken as commercially dry steam or such as is delivered by a good boiler under ordinary conditions.

By superdried steam the author means steam which is not only thoroughly dried in the superheater, but which is raised in temperature thirty or forty degrees above the saturation point, or just enough to insure its arriving at the engine in a perfectly dry state. To such an arrangement there could possibly be no objection, as the steam is delivered at the engine free from moisture and without the use of a separator or means of trapping out condensation.

By a moderate superheat is meant from 100 to 150 degrees at the boiler, which should give in the neighborhood of 100 degrees at the engine and be sufficient, with proper protection, to carry the steam nearly if not quite through one cylinder without condensation. If the engine is compound, the steam, having lost its heat at the terminal point of the high-pressure cylinder, is re-superheated about 100 degrees in a reheater between the high and low-pressure cylinder, will give an excess of superheat while expanding into the low-pressure cylinder, arriving at the point of exhaust with the temperature of saturation. This arrangement may be considered at the present time as the best which can be proposed. The amount of superheat is so moderate as not to require anything more than good construction for modern high-steam pressure.

Highly superheated steam must be treated with more consideration. Engines which will stand a temperature of 500 degrees Fahr. are not necessarily fitted to handle steam at 750 degrees, but these temperatures may be, and have been repeatedly, used successfully. To employ these high temperatures, it is at present considered important to use poppet valves on the high-pressure cylinders at least, as it is here that the full effect of superheat is felt, and this type of valve is easier to lubricate and does not become distorted with heat. The author believes, however, that a Corliss valve may be so proportioned as to operate successfully under even these conditions.

One of the well-known methods of utilizing high superheat is that known as the Schmidt system. This consists in passing a portion of the highly superheated steam directly from the boiler through the reheating tubes of a receiver, between the high and low-pressure cylinders of a compound engine, and then letting this steam mix with that which enters the high-pressure cylinder direct from the boiler. The high-pressure exhaust is thus superheated on its way to the low-pressure cylinder, while the temperature of the steam admitted to the high-pressure cyinder is modified by its admixture with steam which has already been through the reheater coils; and, incidentally, a receiver drain is unnecessary. Automatic regulation of the superheat to a desirable point in each cylinder under a varying load is claimed for this system. Ordinarily an increase of load beyond normal, necessitating a late point of cut-off in the high-pressure cylinder, will give an excess of superheat in this cylinder, while the reheater will not be sufficiently active to superheat this steam on its way to the second cylinder. With the Schmidt system, however, the effect is reversed by causing a greater amount of steam to pass through the receiver coils, where it gives up its superheat to the low-pressure cylinder during periods of heavy draught, and the high-pressure cylinder is thus protected from excessive heat. The contrary effect in both instances may be followed through in case of an engine running under a light load.

In the present state of the art it would seem that the condition most attractive to American engine builders would be one of moderate superheat. We thus confine ourselves to a conservative policy and avoid the necessity for making any special provision for extremely high temperature. We use lubricants, gaskets and packing which may be obtained in open market at a reasonable cost, while at the same time we avail ourselves of such positive and direct benefits of superheating as dry steam in the pipes and throughout the engine; elimination of the separator; low steam consumption per unit of work done; smaller steam pipes and ports; a simplified system of steam jackets; a greater amount of work done per unit of boiler capacity, and better efficiency at light loads. These are all practical improvements, and are of such proportion as to justify attention.

The absence of water with the steam need not be dwelt upon. Every practical man will admit that this is of great value. It is further noticeable that a steam pipe system which will show leakage at the joints with saturated steam will become perfectly tight under superheated steam.

The point of maximum economy while using superheated steam has by no means been reached. The amount of data available is not in proportion to the extent of the practice.

In order to make a comparison between superheated and saturated steam consumption of an engine it is, of course, only fair to place both on a heat unit basis, thus eliminating entirely the question of the cost of the superheat. Assuming a compound engine of about 1000 horse-power and running with 150 lbs. initial pressure and 26 ins. vacuum, we would consider 12½ lbs. of fuel per indicated horse-power per hour a very good result. I have authentic reports of a similar engine supplied with steam with a temperature of 720 degrees Fahr. at the boiler, consuming less than 9 lbs. of steam per indicated horse-power, or a gain of 39 per cent in economy with an expenditure of but 16 per cent more heat units in the boiler.

The reduction in the size of steam pipes and ports rendered possible by using superheated steam is due to the diminished density of an equal volume as compared with saturated steam, as well as from the absence of entrained water. The velocity of superheated steam in pipes should be kept up in the neighborhood of 6000 feet per minute. As a rough approximation it may be said that superheating will make a difference of 20 per cent in the size of the steam pipe.

The question of steam jackets on a cylinder, which has been given so much profound attention in recent years, is quickly solved by the aid of superheated steam, and we see disappear at once the benefit of the jacket as a steam economizer. There seems to be no excuse for retaining the jacket on the low-pressure cylinder, and indeed we have proved by trial that on this cylinder a steam jacket is positively wasteful.

We do not think it is clearly proved, however, that they may not still be useful when applied to the high-pressure cylinder, if only for the sake of warming up a large engine preliminary to starting.

The effect of getting more work out of a certain volume of steam is naturally felt in the handling of the boilers and in a reduction of fires necessary to do a given amount of work. Unexpected results have been frequently obtained by the addition of a superheater to a boiler and a higher evaporative efficiency with the superheater in commission has been shown. This is doubtless due to the increase of the heating surface and the lowering of the temperature of the flue gases. In such cases the saving by superheating is felt in the coal pile to the same extent as in the steam consumption.

On the acceptance test of some vertical compound engines of 1200 and 2400 horse-power on electric light service in Boston the maintaining of efficiency under light loads was well demonstrated. The feed water per indicated horse-power per hour was 12.54, 12.51 and 12 lbs., at full load, three-quarter load and one-half load, respectively, while the amount of superheat was 80 degrees, 64 degrees and 48 degrees, respectively, at the high-pressure admission and 60 degrees, 67 degrees and 84 degrees, respectively, at the low-pressure admission. The engine had reheaters and steam jackets on both cylinders, and it is not unlikely that still better results would have been obtained had the low-pressure cylinder jackets been omitted.

It must not be considered necessary to make any very extensive preparations for the use of superheated steam; it may almost be said that the requirements are merely in the line of good practice, and, as such, should be inaugurated in any event. It is important to have the joints of the steam pipes firmly made and well bolted; corrugated brass gaskets are usually found very satisfactory with superheated steam. Provision must, of course, be made for the expansion and contraction of the steam lines to a somewhat greater extent than ordinarily, and the steam pipes, including flanged unions, should be covered with a thick layer of good non-conducting material. It is important to have the flanged unions covered as well as the pipe. With proper precautions of this sort and with a velocity of steam in the pipes of from 4000 to 6000 feet per minute, the drop in temperature per foot of run may easily be kept down to one degree in six or seven feet of length.

Metal of low melting point must, of course, be avoided in the construction of the engine, especially about the valves and piston rods. The stuffing box bushings must be made of metal which will not run under the temperature likely to be encountered. The metal should be uniformly distributed in designing the valves and cylinders to get the best results with superheated steam, as in this way a uniform expansion by heat is provided for. The barrels of the cylinders are preferably made without projections or ribs. The poppet valve has the advantage in form, but the Corliss valve is also made in such a manner as to expand and contract without warping, and the large number of Corliss engines using superheated steam is a strong evidence of their adaptability.

The lubrication of the cylinders is apt to cause one who has not had experience with superheated steam a great deal of unnecessary anxiety, but really this problem is very simple. It must be borne in mind that the temperature inside of the cylinder is never very high, even when the superheat at the entrance is very considerable, and if the cylinder is lubricated directly without mixing the oil with the steam at the entrance point there can possibly be no difficulty. With any reasonably good grade of mineral oil, however, it cannot be claimed that any difficulty has been experienced with the lubrication of the parts, even when applied in the ordinary way.

The effect of superheated steam on the indicator diagrams is worthy of notice. Steam being used as a perfect gas, the diagram approaches more nearly the theoretical, and, as there can be no re-evaporation in the cylinder, there is no tendency of the pressure to rise during the stroke, and the amount of work done in the low-pressure cylinder is brought down to the proper point.

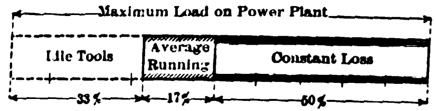
[The foregoing is an abstract of a paper read before the Engine Builders' Association, December 2, 1902.]

THE OPERATION OF MACHINE SHOPS BY INDIVIDUAL ELECTRIC MOTORS.

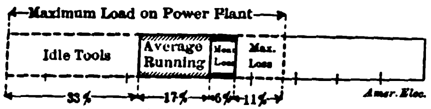
BY R. T. E. LOZIER.

The individually applied motor is now accepted as an established feature of every machine shop. The period of careful investigation, followed by that of cautious probation, is passed, and this type of power application has now been in practical service sufficiently long to provide data that can be studied with profit. These data enable one to make more accurate deductions than were possible in the past, and enable those unfamiliar with the art to undertake its application with greater certainty of results.

From the data that have been collected on power transmission in industrial shops, much of which is to be found in the transactions of the various engineering societies and in the magazines, it appears that if a certain maximum horse-power is required by all the tools of a shop, say, 100 horse-power, it will require at least 100 horse-power additional to transmit this effective power by belts and shafting. This loss of 100 horse-power remains constant whether the effective horse-power is reduced or not. This means that 200 horse-power must be generated. Should these same tools be driven by individual motors, instead of 100 horse-power being required for transmission only 43 horse-power is required, even if every tool is running; but it is found that in the average industrial shop every tool is not running at the same time, some being shut down and others operating on lower than maximum speeds, thus requiring less horse-power. It has been determined practically that in the ordinary manufacturing establishment the mean effective power is but 30 per cent of the total aggregate effective power which is required when all the tools are running at maximum load. This percentage is termed the load-factor. In the case of belt-drive there is, then, 100 horse-power assumed loss for 100 horse-power effective load; that is, an efficiency of 50 per cent. Applying the load-factor as above, it is found that there is but 30 mean horse-power to use and that it requires 100 horse-power to transmit it, thus giving the real efficiency as only 23 per cent. With the individual motor drive the loss varies with the load. Taking the same load-factor, and assuming 30 per cent as representing the loss incurred by the 30 horse-power effective load, there is but 9 horse-power loss against 100 horse-power with the belt drive. Thus, with individual drive, there is generated 39 horse-power, of which 30 is effective, giving an efficiency of 77 per cent against 23 per cent by the shaft and belt method.



All Belt Drive



Individual Drive

FIGS. 1 AND 2.

A graphic demonstration of the foregoing is to be found in Figs. 1 and 2.

In a paper read by the author before the New York Electrical Society in November, 1901, it was shown that assuming steam power to cost $36 per horse-power per year (or 3,000 hours), with the shaft and belt system the power would amount to 2 per cent of the cost of the establishment's product. With subdivided motors it would be 1 per cent, and with individually driven motors it would be something less than four-tenths of one per cent of the cost of the product, so that assuming a plant with an output of $1,000,000 a year, the following statement results:

Method of Drive.	Cost of Power.	Yearly Saving.
Belts and shafting........	$17,000	.....
Subdivided motors	8,500	$8,500
Individual motors	4,000	13,000

From such information as the author has been able to obtain since that time, the above figures are correct. These data relate to the average machine shop, and not to establishments run under conditions peculiar to their line of work, and which must be put in a class by themselves, the law of averages being applied to their peculiar conditions.

Assume that in the average machine shop 60 per cent of the motors installed are to have variable speeds. These variable-speed motors will have a rated capacity considerably higher than the average amount of power they will be called upon to supply. Concerning the other 40 per cent of motors, assume that their rated capacity represents the exact amount of power that they will consume—and this assumption is justified because their speed is not varied. Of the sum of the aggregate rated capacity of the variable-speed motors and that of the constant-speed motors, 35 per cent fairly represents the mean power that all of these motors will be required to furnish, if they are all running at the same time. This mean power, of course, varies with that percentage which the variable-speed motors bear to the total installation. If the load-factor of 30 per cent be now applied, which provides for the shut down of tools and reduction in the power due to slow speed, it is found that the average power that must be provided by the generating plant is but 10.5 per cent or the aggregate rated capacity of the individual motors installed. While it is true that 60 per cent of the motors has a much larger rated capacity than is actually required, still this very small amount of power required is an evidence of the remarkable efficiency of the individual drive system. It cannot be assumed that this 10.5 per cent is the capacity of the generating plant, because a provision must be made for a maximum condition inasmuch as that percentage represents but a mean condition. However, the system is so efficient that ample margins of, say, 100 or 200 per cent can be applied, which may also provide for "stand-by" purposes. And yet the purchaser, by applying his individual motor system, comes well within that power plant which he would otherwise have to supply to meet the mean conditions of a belted plant, without providing any spares of the latter. The author feels that if it were not for the empirical data presented time would have been wasted by stating an already well-accepted fact; i. e., that the individual motor drive is highly efficient and many times more so than the old system of belt transmission, or its modification of using belted motors in groups. It is not claimed that the latter itself has not a sphere of usefulness and a large one, the foregoing being merely a comparison of the relative economy of these different systems. It would not be possible to use the individual motor, if means were not available for successfully varying its speed.

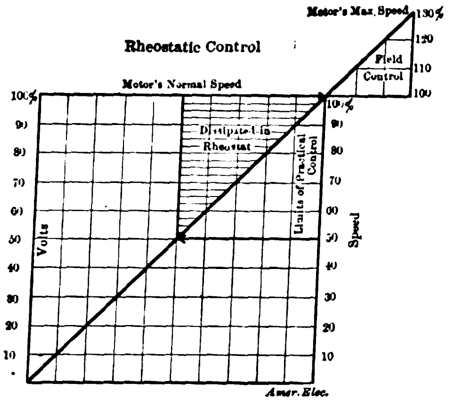


FIG. 3.

To control the speed of a motor, it is necessary to apply to the armature terminals a voltage corresponding to the speed desired. This can be accomplished in several ways:

The Rheostatic Method.—In this case the current is generated at any common source of supply at a fixed pressure or voltage. Before reaching the motor, it is passed through a resistance which is adjusted to consume just so much of the pressure as will reduce the speed of the motor to the point desired. This method has three limitations, viz.: (*a*) That if the load put upon the motor varies, the portion of the voltage consumed in the rheostat is altered, and this changes the speed of the motor, a thing which may not be desirable; (*b*) the system is inefficient, because that percentage of the voltage which is consumed by the rheostat represents a dead loss; and (*c*) the dimensions of the rheostat necessary to dissipate the energy may reach an inconvenient size. Within its limitations, however, the rheostat system of control can be made very useful. Fig. 3 is a diagrammatic explanation of this system. It will be seen that the motor cannot be reduced from its normal speed more than 50 per cent, because below that point the fluctuations in speed, due to variations in torque, are too great.

Multi-voltage Method.—This method consists essentially in supplying the motor with as many different voltages as are necessary to cover the desired range of speed. In its simplest form this method consists of generators, each adjusted for different potentials. This, however, is not necessary, because it has been found that where several motors are involved they will balance up against each other in such a way as to divide among themselves the full voltage, so as to give the respective desired speeds. It is, therefore, only necessary to supply the main generating plant with a small balancer to take up any differences that there may be. By dividing the voltage at three points, there are six possible combinations, which successfully cover the full range of speed as far as general requirements are concerned. The advantages of this system are: (*a*) That any one of the lower steps can be maintained constantly and quite independent of variations in the torque or load upon the motor—this is absolutely essential to tool operation; (*b*) that the system is highly efficient; (*c*) that appliances to control it are of very small dimensions and convenient to operate (see Figs. 4 and 5).

Special Methods.—In this class are to be found various methods which have been devised to meet the special requirements of some one power application. In this class is to be found the teaser system. Fig. 6 has been designed to take care of unusually heavy starting conditions, such as are to be found in large printing presses. In such cases they can also be operated at a very low rate of speed. The method consists essentially in employing a small motor, which takes current from the main source of supply at the full voltage. This motor drives a small generator wound with large current capacity, which it supplies to the main working motor when the latter starts, but at low voltage, because the speed is very slow. It is because of the latter fact, and further because it is in service for so

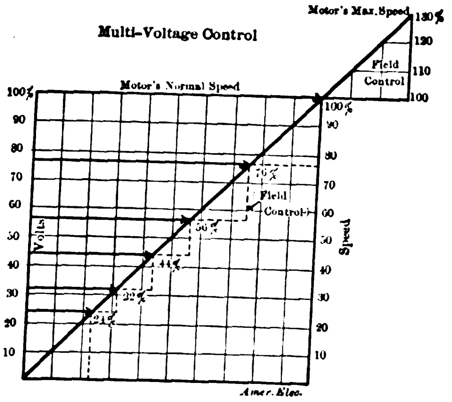


FIG. 4.

small a space of time that the apparatus can be made small.

Field Control.—The foregoing methods vary the voltages applied to the terminals of the motor armature. There is a method of changing the speed by varying the field strength of the motor and in that way changing the counter e.m.f. at a given speed e.m.f. This has two limitations: (*a*) the first one met with in practice, viz., that as the field of the motor is weakened it goes farther and farther off from its electric balance, and its distress is soon evidenced by sparking at the commutator, due to reaction of the armature upon the weakened field; (*b*) the torque will fail, if the field is weakened beyond a given point. In a motor designed to come fairly well up to the limitations of its normal rating, its speed should not be increased more than 30 per cent. If, however, the motor is large for its work, i. e., under rated, according to commercial standards, then, of course, its speed can be increased until the limiting conditions of speed control, as established by its rating, are again reached. Or if the motor is operating at a lower potential impressed upon its armature than that of its normal rating, its speed may be increased over a larger range by weakening its field. But, generally speaking, it is well to understand that field control, while most useful within its limitations, cannot be successfully carried beyond such limitations and, generally speaking, such limitations represent an increase of not more than 30 per cent. of the normal speed of the motor. It must always be remembered that field control increases the normal speed of the motor and does not decrease it.

In combination with the multi-voltage system—which is available for producing certain speeds that remain constant, even with varying torque, throughout the entire range—can be used the rheostatic control for reducing any one of the fixed speeds down to the next fixed speed. Field control can also be used for increasing any one of the fixed speeds, up to its next graduation. By these means, speed increments as finely divided as one pleases can be obtained, that will carry the speed of the motor from zero to maximum, with high efficiencies and practical constancy at any one point, despite varying torque. The multi-voltage is depended upon to form the framework of the speed control, while the rheostatic and field control supply the detailed elaboration, where such may be necessary. The multi-voltage is carried throughout the entire plant, usually by two conductors in addition to the two main circuits, while the rheostatic and field control is applied locally as circumstances may require.

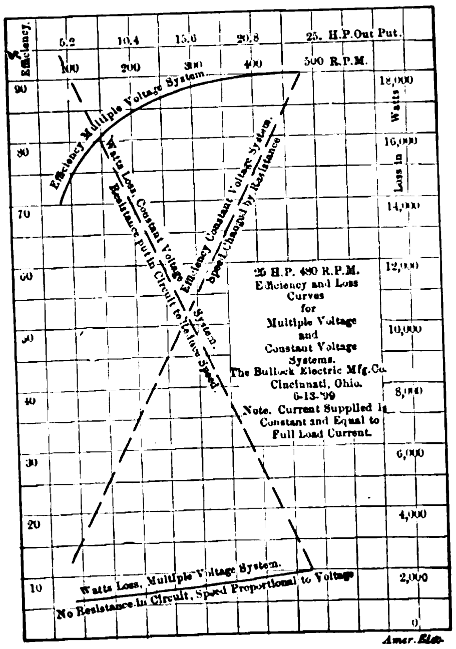


FIG. 5.

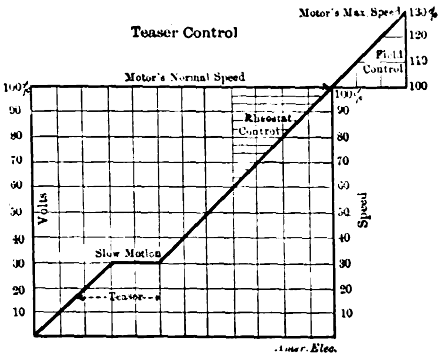


FIG. 6.

Thomas A. Edison marked an important epoch, about seven years ago, when in his great ore milling undertaking he put into operation a principle that had long been accepted by him—that machinery and equipments were cheaper than labor and general expense and that it was better to use up your machinery at a high rate, if by so doing you materially increased your output.

About four years ago the matter of determining exactly the speed limitations of iron working machinery was taken up by a few enterprising engineers and these limits have since then been kept in view with the greatest amount of success. Where before the old thumb rule governed, now the slide rule has taken its place. While labor was bitterly opposed to the principle of the employer inducing his operators by additional incentive, to work up to the highest efficiency—which incentive was withdrawn when that point was reached, and their wages, perhaps, still further reduced should they fall behind—they have been led to recognize the benefits to be obtained by securing to the operator his mean wage, allowing him to share in the benefit gained by his working up to his normal capacity. These methods at present come within two general classifications. I will mention them here, because they are pertinent to the general subject of variable speed control. The first is the premium system, in which the law of averages is applied to past work and the result is taken as a standard for determining what can be done in the future. This determines the minimum space of time in order to provide for the increased efficiency at which the man is supposed to work. Now, if a man is able to improve upon that time, he is given a *pro rata* share of the gain. This system is based upon empirical data. The other system is more recent and is known as the bonus plan. The method is as follows: First, the limit of speed and depth of the cutting tool are determined, then the area to be traversed by that tool determined the minimum space of time in which the tool can traverse it at its maximum cutting speed and depth. In making this calculation, it is assumed that the operator has always available the speed that represents the maximum limitations of the tool. Stability of the machine tool itself, and the capacity of the power transmitted to do the work, must be carefully considered. The operator is given explicit directions as to the shape of the cutting tool, the feeds, speeds and general methods to be applied in doing the work and the exact time involved in such method is also given him. These instruction cards are not only theoretically correct, but state conditions that can easily be obtained in practice. If the operator succeeds in meeting these conditions, he not only receives his regular pay, but is also presented with a fixed bonus. With such a method of operation as has just been described, the practical operator immediately recognizes the essential points.

The limit of high-speed operation is not to be found in cutting tools, or in the ability of motors to successfully do the work and to vary their speed, or to the motors' first cost, but is to be found in the stability of the machine tool itself, which is generally designed to stand the lower strains and the smaller powers required by the old cutting rates. I have prepared a table which I believe fairly well represents what was possible in the way of cutting speeds, four years ago, and what can be readily obtained in practice to-day, provided the machine tool can stand the strain.

CUTTING RATE—REVOLVING.

Material.	By Old Methods. Feet.	New Methods.* Feet.	Cut. Inches.	Feed. Inches.
Cast iron	20	60-80	⅜	⅛
Forged steel, unannealed	12	40-60	⅜	⅛
Steel casting	10	40-70	⅜	⅛

* Using Novo, Taylor White or First Sterling tool steel.

It is interesting to point out in connection with this table, that at these high-cutting rates a speed range must be provided to allow for the variation in the material itself and therein the variable speed motor, with its large range of easily selected speeds, serves a most important function.

The Bickford Drill and Tool Company gives some interesting information as to progress in increased cutting speeds for drills. While two years ago the speed ranged from 9 to 188 revolutions and the feed ranged from 0.005 in. to 0.007 in., they are now enabled to drill a ⅜-in. (0.375-in.) hole at a feed of 1/16 in. (0.06 in.) per revolution.

[The foregoing is a paper read at a recent meeting of the American Institute of Electrical Engineers.]

DETERMINATION OF INDUCTION MOTOR CHARACTERISTIC CURVES.

BY A. S. M'ALLISTER.

With almost no exception, the graphical method of treatment of electrical phenomena does not produce results as accurate as the analytical; yet, for many purposes where a fine degree of accuracy is not required, the ease of manipulating has led to the extensive use of the graphical method, approximate results being first rapidly determined, after which if greater accuracy is desired, the analytical method may be used. In cases where only qualitative results are desired; but where some knowledge of the effect of change in the different variables connected with the phenomena is important, the graphical method, because of its simplicity, readily lends itself to the quick determination of results sufficiently accurate for the needs of the case.

By means of such diagrams one is able to follow optically, and thus mentally, the changes which take place throughout the operation of an induction motor; while in the manipulation of algebraic formulas one is apt to find himself more or less in the dark concerning these changes.

Though some advantages may be claimed for the method of dividing the amount of energy supplied to a polyphase motor by the number of phases and then treating the machine as that number of single-phase motors, greater simplicity is introduced into the calculation if equivalent single-phase qualities be determined for the polyphase circuit. In accordance with this plan the total number of watts supplied to the circuit is used in computations without alteration, the measured e.m.f. of the polyphase circuit is considered the equivalent single-phase e.m.f., while the equivalent effective current is understood to mean that value of current which must flow at the same power-factor in a single-phase circuit at the same voltage to transmit the same power.

It is evident that in a two-phase circuit the sum of the currents of the separate phases is the equivalent single-phase current. This quality will hereafter be referred to as the "total current," or as simply the "current" of the two-phase circuit. Since the total energy transmitted in a three-phase system is expressed by $W = \sqrt{3}\, I\, E \operatorname{Cos} \theta$, $\sqrt{3}\, I$ is the equivalent effective current. In the equation above I is the current per wire. For a delta-connected receiver the current per phase is equal to $I \div \sqrt{3}$, or the sum for the three phases is $3 I \div \sqrt{3} = \sqrt{3}\, I$. The quantity $\sqrt{3}\, I$ has, therefore, a physical significance as the total current of a delta-connected receiver, though in a star-connected machine such quantity exists only mathematically. However, for the sake of combined generality of treatment and brevity of discussion, $\sqrt{3}\, I$ will hereafter be spoken of as the "total current," or the "current" of the three-phase circuit.

In determining the copper loss of a given piece of polyphase apparatus, it is convenient to know what value of resistance must be taken so that the square of the total current may, by its multiplication therewith, give the actual copper loss when the corresponding current flows in the circuit. The following very simple ratio is found to exist between the resistance of a given circuit as measured by direct-current instruments and the equivalent resistance for the total current:

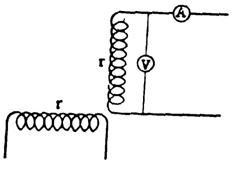


FIG. 1.

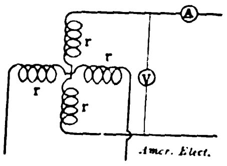


FIG. 2.

For any two-phase receiver with independent, star, three-wire, or mesh-connected coils, or for any three-phase receiver with delta, star or combination-connected coils, the equivalent resistance for the total current is equal to *one-half* of the value measured between phase lines by direct-current instruments.

The proof of the above fact for circuits connected as shown by Figs. 1, 2 and 3, is self-evident and no explanation need be given.

Referring to Fig. 4, let r = resistance per quarter; then $2r \div 2 = r = R$ resistance measured by direct-current instruments. Let i = current per coil; then $\sqrt{2} \times i$ = current per lead and $2\sqrt{2} \times i$ = total current. Evidently the copper loss is $4\, i^2 r$. Using the total current as above and $R \div 2$ as the equivalent resistance the copper loss is $(2\sqrt{2} \times i)^2 \times r \div 2 = 4\, i^2 r$.

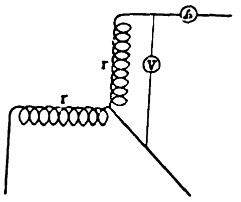


FIG. 3.

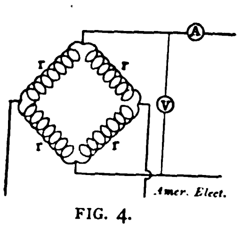


FIG. 4.

In Fig. 6, let r = resistance per coil; then $2\, r = R$ = resistance measured. And if i = current per coil, then $\sqrt{3} \times i$ = total current. The copper loss is $3\, i\, r$. Using the total current and equivalent resistance, the loss is $(\sqrt{3} \times i)^2 r = 3\, i^2 r$.

In the delta-connected circuit of Fig. 5, let r = resistance per coil; then $2\, r \div 3 = R$ = resistance measured. Let i = current per coil; then $3\, i$ = total current, and the copper loss is $3\, i^2 r$. For equivalent single-phase quantities the loss is $(3\, i)^2 \dfrac{2\, r}{2 \times 3} = 3\, i^2 r$.

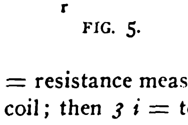


FIG. 5.

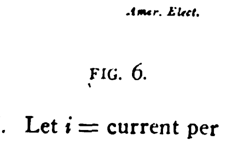


FIG. 6.

Since the ratio of effective resistance for the total current to the measured resistance is the same for star and delta-connected, three-phase circuits, the same ratio must evidently hold for a combination of the two connections.

Before discussing the graphical diagram for the representation of the value and phase of primary and secondary currents of an induction motor, it is well to establish the similarity between an induction motor and a static transformer.

At any value of field magnetism, the effect of inserting resistance in the secondary of an induction motor, for a given value of secondary current, is to vary the slip directly with the total secondary resistance without affecting either the torque or the power-factor.

As proof of this fact, let E_2 = the e.m.f. which would be generated in the secondary at 100 per cent. slip, at the given field magnetism,

s = slip in per cent,
R_2 = secondary resistance,
X_2 = secondary reactance at 100 per cent slip (standstill),
I_2 = secondary current.

Then $I_2 = \dfrac{s\, E_2}{\sqrt{R_2^2 + s^2 X_2^2}}$ or $I_2^2 = \dfrac{s^2 E_2^2}{R_2^2 + s^2 X_2^2}$.

or, since I_2 and E_2 are constant for the chosen condition of service,

$$K'^2 = \frac{s_2}{R_2^2 + s^2 X_2^2}$$

$$s^2 = \left(\frac{K'^2}{1 - K'^2 X_2^2}\right) R_2^2 = a^2 R_2^2$$

or the slip is directly proportional to the secondary resistance. The secondary power-factor, $p_2 = \dfrac{R_2}{\sqrt{R_2^2 + s^2 X_2^2}} = \dfrac{R_2}{\sqrt{R_2^2}\,\sqrt{1 + a^2 X_2^2}} = \dfrac{1}{\sqrt{1 + a^2 X_2^2}}$

or the secondary power-factor is independent of the secondary resistance.

The total secondary energy is $I_2\, E_2\, p_2$, and is independent of the secondary resistance, while the torque, which is $7.04 \dfrac{I_2\, E_2\, p_2}{\text{syn. speed}}$, is also independent of the secondary resistance.

Since the effect of inserting resistance in the secondary circuit is merely to increase the slip without altering the other qualities, it follows that by using suitable selected resistances, the slip can be made unity for any value of secondary current at the corresponding power-factor. In consequence of this fact, the performance of the secondary will be faithfully represented if all the energy received from the primary be considered as dissipated in resistance in the secondary circuit, the slip at all times being taken as unity and the total secondary resistance (conductance) being assumed to be varied according to the secondary load, or briefly, the induction motor may be treated in all respects like a stationary transformer. The determination of the slip, torque, etc., of the motor under operating conditions will be discussed later.

Perhaps of all the graphical diagrams which have been suggested at various times to represent the performance of an induction motor the simplest, and at the same time the most complete, is that showing the valve and phase of the primary and secondary currents. The quantities intended to be represented by this diagram can best be ascertained by investigating the method of determining points on the current locus, such as is shown in Fig. 7, which is plotted according to the following instructions:

Use the horizontal scale to plot values of the power component of the currents ($I \cos \theta$), and the vertical scale, the same number of amperes per inch, to plot the wattless components of the currents ($I \sin \theta$).

From the origin *O*, lay off a distance *OB* equal to the power component of the primary current at no load, and from the point *B* erect the perpendicular *B A* with a value equal to that of the wattless component of the primary current at no load. The distance *O A* represents the no-load primary current, while the angle *A O B* is the primary angle of lag at no load. In a similar manner, selecting any load current, as *O C*, lay off the power and wattless components, *O D* and *D C*. The angle of lag is represented by the angle *C O D*. Following out the same method, locate a number of points corresponding to the points *A* and *C* and draw a smooth curve through them at any point on this curve, as *P*.

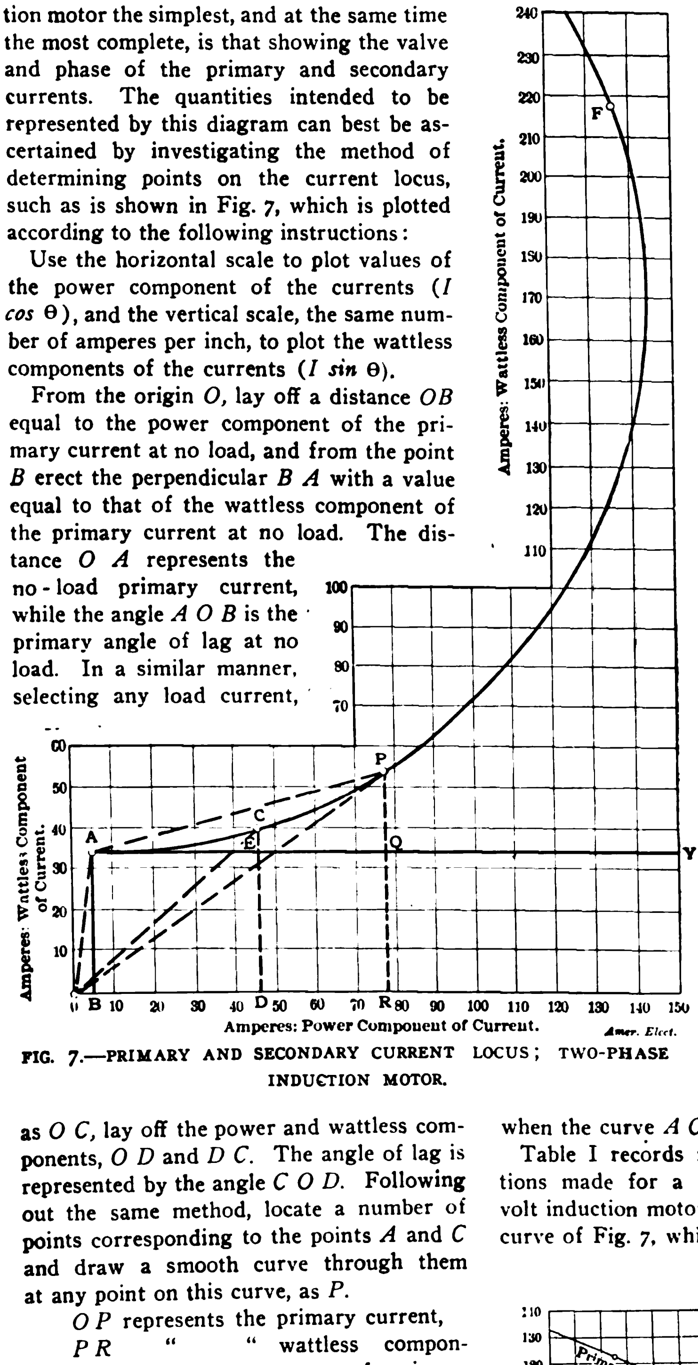


FIG. 7.—PRIMARY AND SECONDARY CURRENT LOCUS; TWO-PHASE INDUCTION MOTOR.

O P represents the primary current,
P R " " wattless component of primary current,
O R " " power component of primary current,
P O R " " primary angle of lag,
P Q " " wattless component of secondary current,
A Q " " power component of secondary current,
A P " " secondary current,
P A G " " secondary angle of lag.

The proof of the representation of secondary qualities is as follows: When running under a load, *O R* represents the power component of the primary current, while *B R* equals the increase in the power component over its no-load value. As in a transformer, this increase is due to the flow of current in the secondary, and being in phase (opposition) to the power component of the secondary current, it is a direct measure of its value. A similar course of reasoning holds for the wattless component *P Q*. Hence *A P* represents the secondary current both in value and phase.

An inspection of the diagram will show that the maximum secondary power-factor occurs at no load, while the maximum primary power-factor occurs at that load which causes the line *O P* to become tangent to the curve *A C P F*. Since the no-load losses are equal to the product of *O B* × the primary e.m.f., and the secondary current, primary current and power-factor can be obtained directly from the curve for any value of primary load, it follows that if the primary and secondary resistances be known, the input, losses, output, efficiency, slip, speed, power factor and apparent efficiency can easily be determined when the curve *A C P F* is located.

Table I records results of such calculations made for a 10-h.p., two-phase, 220-volt induction motor, use being made of the curve of Fig. 7, which has been constructed in part from data obtained from this machine. Results found in Table I have been plotted in the form of the curves shown in Figs. 8 and 9, from which can be ascertained the complete performance of the motor from no load to full load and beyond. This motor is supplied with a resistance external to the secondary windings for the purpose of decreasing the primary current and increasing the rotor torque during the period of starting from standstill. The effect of using this resistance is seen at a glance when Fig. 9 is compared with Fig. 8. While the method of calculation used in arriving at the results given in each column of Table I is explained fully at the heads of the separate columns, perhaps a few words should be added concerning the formulas for determining the slip and the torque. The rotor slip in per cent is equal to the ratio of the copper loss of the secondary to the total power received from the primary; that is, $s = \frac{I_2^2 R_2}{W_s}$, where W_s is the total secondary power.

$$W_s = I_2 E_2 p_2$$

$$I_2 = \frac{s E_2}{\sqrt{R_2^2 + s^2 X_2^2}} \quad \text{whence}$$

$$\frac{I_2^2 R_2}{I_2 E_2 p_2} = \frac{s E_2 R_2}{\sqrt{R_2^2 + s^2 X_2^2}\, p_2} = s, \text{ since}$$

$$\frac{R_2}{\sqrt{R_2^2 + s^2 X_2^2}} = p_2$$

The rotor torque is expressed in pounds at one foot radius by the formula

$$T = 7.04 \frac{W_s}{\text{syn. speed}}.$$

Since the product of torque and speed gives power when expressed in proper terms, the energy delivered by the motor in horse-power is,

$$\frac{T \times 2\pi \times r.p.m.}{33{,}000} \text{ or}$$

$$W_o = \frac{T \times 2\pi \times r.p.m. \times 746}{33{,}000}$$

where W_o is the secondary output in watts.

$$W_o = \frac{T \times r.p.m.}{7.04}$$

but $W_o = W_s - I_2^2 R_2 = W_s (1 - s)$; and $r.p.m. = \text{syn. speed } (1 - s)$; so that

$$T = \frac{7.04\, W_s (1 - s)}{\text{syn. speed} (1 - s)} \text{ as stated above.}$$

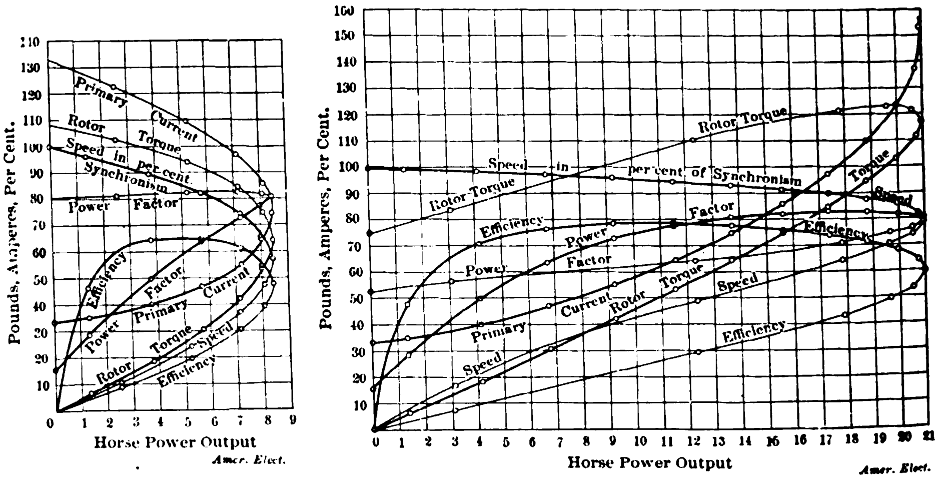


FIG. 8.—CURVES SHOWING PERFORMANCE OF TWO-PHASE INDUCTION MOTOR.—FIG. 9.

It will be observed from column 7, Table I, that there is added to the primary copper loss a quantity, 856 watts, to obtain the total primary loss. The 856 watts is the so-called constant loss and includes all iron and friction losses of the motor. It should be carefully noted in this connection that this loss is not constant, but increases with increase of load, due to the presence at low speeds of a secondary iron loss, which is practically absent at synchronous speed and to an increase in the primary iron loss with the distortion of field magnetism under load. When the character of the work necessitates such procedure, this increase can be approximately determined and corresponding corrections made, though other errors in computations or assumptions will frequently more than equal that due to the neglect of this increase.

Referring now to Fig. 7, it will be seen that the curve *A C P F*, the current locus, has been drawn as the arc of a circle. This is the construction usually adopted for the purposes of preliminary design, in which case the point *F* is located as the extremity of the vector representing the value and phase of the primary current, which would be obtained with full e.m.f. impressed upon the motor with the rotor stationary. This construction is partly justified by the following fact:

If the primary resistance and the exciting current be neglected, or the secondary current be considered equal to the primary, the current locus is a true circle.

Let E = impressed e.m.f.,
I = current to the motor,
X_1 = primary reactance,
X_2 = secondary resistance,
R_2 = secondary resistance.

Treating the induction motor as a transformer, the value of the current as R_2 is varied is $I = \dfrac{E}{\sqrt{(X_1 \times X_2)^2 + R_2^2}}$

but $R_2 = (X_1 \times X_2)\ cotan\ \theta$; hence $I =$

$$\frac{E}{X_1 \times X_2)\sqrt{1 + cotan^2\,\theta}} = \frac{E}{X_1 + X_2} \sin\theta$$

which, when E is constant, is the polar equation of a circle having a diameter of $E \div (X_1 + X_2)$.

If the primary current at all times differed in value from the secondary current by a constant amount equal to the no-load current, the above equation would yet hold true for the secondary current locus. Since, however, such is not the case, the secondary current locus is not a true circle, nor can any one curve be used to determine accurately the value of the secondary current by the method employed above, even if the primary resistance were truly negligible. The effect of the primary resistance is the same in all respects as though the primary coils were without resistance and the power supplied to the motor were transmitted over a circuit having resistance equal to that of the primary, which means that in the equation, E decreases with an increase of I, and the equation is, therefore, not that of a true circle.

Having drawn attention to these errors in the assumptions concerning the current locus, it is sufficient here to state that while the method used does not give the absolutely true location of the primary current curve throughout its whole length, and the absolutely true secondary current curve does not coincide with that of the primary, the errors introduced into the calculations are relatively small and for most practical purposes may well be neglected.

is provided which can be used on any of the

TABLE I.

PRIMARY RESISTANCE PER PHASE = .48 OHMS.									SEC. RES. PER PHASE = .15 OHMS.						SEC. RES. PER PHASE = .50 OHMS.					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	10)	(11)	(12)	(13)	(14)	(15)	(10)′	(11)′	(12)	(13)′	(14)′	(15)′
FROM CURVE, Fig. 7.			$\frac{(1)}{2}$	220(1)	$.24(2)^2$	(6)+856	(5)−(7)	$\frac{(8)}{170.4}$	$.25(3)^2$	$\frac{(10)}{8}$	$100\,[1-(11)]$	(8)-(10)	$10\,\frac{(5)}{(13)}$	$\frac{(13)}{746}$	$1.5(3)$	$\frac{(10)'}{(8)}$	$100\,[1-(11)']$	(8)-(10)′	$100\,\frac{(5)}{(13)'}$	$\frac{(13)'}{746}$
Power component of primary current.	Total primary current.	Total secondary current.	Power-factor.	Watts. Input to motor.	Watts. Primary copper loss.	Watts. Total primary loss.	Watts. Input to secondary.	Pounds. Rotor torque.	Watts. Secondary copper loss	Rotor slip.	Rotor speed. Per cent synchronism.	Watts. Motor output.	Motor efficiency. Per cent.	Motor output. Horse-power.	Watts. Secondary copper loss	Rotor slip.	Rotor speed. Per cent. synchronism.	Watts. Motor output.	Motor efficiency. Per cent.	Motor output. Horse-power.
5.1	33.3	00	.153	1122	266	1122	0000	00	00	.000	100	000	00	0	00	.000	100	000	00.0	0.00
10	35	4.9	.286	2200	294	1150	1050	6.16	6	.006	99.4	1044	47.5	1.40	36	.035	96.5	1014	46.2	1.36
20	40	14.9	.500	4400	384	1240	3160	18.52	55	.017	98.3	3105	70.5	4.17	333	.105	89.5	2827	64.3	3.79
30	47	25	.638	6600	530	1386	5214	30.6	156	.030	97	5058	76.6	6.78	937	.180	82	4277	64.9	5.73
40	55	35	.728	8800	725	1581	7219	42.3	306	.042	95.8	6913	78.5	9.28	1836	.254	74.6	5383	61.2	7.22
50	64.5	46	.775	11000	1000	1856	9144	53.6	528	.058	94.2	8616	78.3	11.58	3170	.347	65.3	5974	54.3	8
60	74.7	56	.804	13200	1332	2188	11012	64.5	783	.071	92.9	10229	77.6	13.73	4700	.427	57.3	6312	47.8	8.46
70	85.6	67	.817	15400	1760	2616	12784	74.9	1123	.088	91.2	11661	75.8	15.64	6740	.528	47.2	6044	39.2	8.10
80	97	78	.825	17600	2260	3116	14484	84.8	1521	.105	89.5	12963	73.7	17.38	9126	.630	37	5358	30.5	7.19
90	109.5	90	.823	19800	2880	3736	16064	94.2	2022	.126	87.4	14042	71	18.82	12140	.756	24.4	3924	19.8	5.26
100	123	102	.813	22000	3635	4491	17509	102.8	2605	.149	85.1	14904	67.8	19.98	15630	.894	10.6	1879	8.5	2.52
110	137	115	.803	24200	4515	5371	18829	110.4	3305	.176	82.4	15524	64.2	20.80	19830	1.056	—5.6	—1001	...	—1.34
120	153	130	.784	26400	5620	6476	19924	117	4220	.212	78.8	15704	59.5	21.03	.....	....	...	....	...	...
130	171	147	.760	28600	7020	7876	20724	121.4	5408	.261	73.9	15316	53.6	20.56	.....	....	...	....	...	...
135	182	158	.742	29700	7960	8816	20884	122.5	6230	.299	70.1	14654	49.3	19.65	.....	....	...	....	...	...
140	197	171	.711	30800	9320	10176	20624	121.1	7310	.354	64.6	13314	43.2	17.86	.....	....	...	....	...	...
144	224	196	.643	31680	12020	12876	18804	110.3	9590	.510	49	9214	29.2	12.38	.....	....	...	....	...	...
140	248	218	.565	30800	14780	15636	14164	83.1	11850	.837	16.3	2314	7.6	3.10	.....	....	...	....	...	...
135	259	226	.522	29700	16040	16896	12804	75.1	12800	1	00.0	000	0.0	0.00	.....	....	...	....	...	...

◆

Safety Valve Area.—The rule of the government inspector is to require a safety-valve area of one square inch for every two square feet of grate surface. The reason is that valves of this dimension will allow the escape of all the steam the boiler is capable of making without materially increasing the pressure.

HIGH PRESSURE STEAM PIPING.

BY WILLIAM ANDREWS.

A modern high-pressure steam job requires, first, good design; second, good material; third, skillful steam fitters. The first requirement can be altered to suit the conditions, but the other two—never.

Up to the year 1900 the almost universal design for a piping system for power plants was to carry a pipe from each boiler into a large steam header, whose cross section was equal to the sum of all the areas of the feeding pipes. If the designing engineer wanted to be very grand, he made it larger, without knowing just why. From this header, pipes of sizes called for by the engine builder were carried to the various engines. It was quite common to place steam separators in each line leading to an engine, but fashions changed in steam piping, as well as in clothes, and with the advent of high pressure and superheated steam, sizes of pipes have been very much reduced.

In the four large power houses now built in New York City, with an ultimate capacity of from 60,000 to 100,000 horse-power each, the largest steam mains are not over 20 inches in diameter, and these are used more as equalizing pipes than storage reservoirs

These pipes before reaching the engine are carried into a wrought iron or steel receiver, which acts also as a separator. This receiver has a cubical capacity of three times that of the high-pressure cylinder, and is placed as near as possible to the cylinder. The pipe from the receiver to the cylinder is of the full size called for by the engine builder. The object of this arrangement is, first, to have a full supply of steam close to the throttle; second, to provide a cushion near the engine on which the blow caused by the cut-off in the steam-chest may be spent, thereby preventing vibrations from being transmitted through the piping system, and, third, to produce a steady and rapid flow of steam in one direction only, by having a small pipe leading into the receiver. This steam flows rapidly enough to make good the loss caused during the first quarter of the stroke.

Plants fitted up in this way are running successfully, with a drop in steam pressure is not greater than 4 pounds, although the engines are 500 feet away from the boilers. This is probably the most radical departure in high-pressure work up to the present time. Allowance for contraction and expansion is provided for by long bends, by using a double swing (like a gas bracket) on which the fittings turn on the threads of the nipple, and by producing what may be called initial tension. This can hardly be described in words, but it is a rule of thumb method by which the skilled steam fitter puts a strain on the pipes when cold, so that when the pressure is put on, the expansion removes this tension and there remains no strain on the pipe other than that due to internal pressure. Expansion joints of the old slip style and those made of corrugated copper have entirely disappeared from the modern first-class job.

As to quality of material, in the earlier days of electric light and railroad plants, owing to the difficulty of keeping the screwed joints tight, some engineers tried flanged cast iron pipe for steam mains, but it was heavy and clumsy, and sometimes cracked on account of the unequal expansion. Then came copper, and this, even when the pipe was reinforced with steel wire wound around it, was found to be a treacherous metal. Flanged cast-steel pipe was tried, but the difficulty of obtaining this free from blow holes barred it out. At present the material used is either wrought steel or wrought iron pipe, on which the flanges are either riveted, screwed or welded.

In 1880 the New York Steam Company installed about six miles of steam mains under the streets of New York for power and heating purposes. All the joints in this pipe above eight inches in diameter were made by expanding the pipe into recesses in the flanges, and then beading the ends of the pipe over the edges of the flanges. This was done by machinery, and was well done, and at the time was considered a great improvement over threading or riveting, but in five years every joint had to be taken out on account of leaks, and threaded joints were substituted. These threaded joints lasted until 1895, when all the pipes were renewed with new mains having heavy wrought steel flanges welded on the pipe. These welded flanges when turned true in the lathe make the most workmanlike and perfect steam joints in use at the present time, and their cost alone prevents their general use.

Gate valves are almost exclusively used in high-pressure work, as globe valves, especially in the larger sizes, would be very clumsy, and they would also make a pocket in the pipe. If gate valves are worked often enough to keep them in good order, they will remain tight many years.

Corrugated copper gaskets placed inside the bolts and well pulled up will make a joint which will last as long as the fittings. The softer gaskets containing rubber, asbestos or lead alloys need constant attention, and when superheat is used they are rapidly destroyed. When the owner's bank account is strong enough, ground joints without any gaskets are used. This makes a first-class job, but the price is all but prohibitive.

One of the very necessary points of a first-class piping job, and one too which is very often overlooked, is to have extra heavy fittings on the gauge, lubricator and high-pressure drip connections. A break in one of these pipes, while it may not shut the station down, would cause great inconvenience and would be a nuisance until it was fixed.

Vibrations which often accompany the installation of high-speed engines in modern buildings are many times laid to the bad foundations or the unbalanced condition of the engine. In almost all cases it is not true; the vibrations come from the bad piping and can be, and in many cases have been, removed without touching the engine or foundations.

[The foregoing is an abstract of a paper read before the Engine Builders' Association December 2, 1902.]

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THE THREE-WIRE SYSTEM FOR VARIABLE-SPEED MOTOR SERVICE.

BY N. W. STORER.

In deciding the type of motor to be used in mills, it is generally recognized that the alternating-current induction motor has its own particular field; the direct-connected and alternating-current motors have a common field, and the direct-connected motor in turn has its own special field. In deciding the method of applying the power, the choice lies between a separate motor for each machine and driving groups of machines from counter shafts driven by constant-speed motors. If individual motors are selected, when variable speed is desired, there is the further choice between the constant-speed motor with mechanical speed-changing devices and a variable-speed motor direct connected to the machine. In this latter class of work is found the special field for the direct-connected motor.

Omitting cranes, street railways, hoists, and other classes of service where the series motor with rheostatic control is used, variable-speed motor work may be divided into three classes, as follows:

(1) Machines requiring a torque increasing with the speed; blowers and fans belong in this class. The power required for the machine increases very rapidly as the speed increases and great care should be exercised in selecting motors for such service. However, as the variation required is usually small, the requirements can be met with standard motors on a single-voltage system. Motors should preferably be compound-wound and the speed should be varied by means of a resistance in the shunt field.

(2) Machines requiring a constant torque. In this class pumps and air compressors are the most conspicuous examples. The speed variation required for such service is usually small, and it is generally best and most economical to supply compound motors and to vary the speed by means of the shunt-field rheostat, as in the case of the fans and blowers. A series winding is especially beneficial for this class of work in preventing the heavy fluctuations of current that would take place with a constant-speed motor in passing through the different parts of the cycle. A compound motor may be used for this work because a constant speed at any point on the controller is not necessary.

(3) Machines requiring approximately the same maximum output at any speed, or a torque varying inversely as the speed. This class includes most of the machine-tool work where automatically constant speed regulation on any notch of the controller is especially desirable. It is, therefore, necessary to use a shunt motor having good inherent regulation.

It is the last-named class of service that has caused the most discussion. Several companies have entered this field with different systems of variable-speed motor control. Some of these companies are able to place their motors on the standard and well-known systems of power distribution, while others seek to introduce special systems. The wirter has been interested in the development of the three-wire system for this class of work, and it is the purpose of this paper to describe the operation and advantages of this system as presented by the Westinghouse Electric & Manufacturing Company.

The standard Edison three-wire system for general power distribution is so well known that it is unnecessary to describe it. The power station equipment, consisting of two 125-volt generators connected in series with the neutral wire brought out between them, is also well known, and the single-voltage generator with a motor-generator set of sufficient capacity to carry the unbalanced current is used in many places. But the type of generator which is rapidly attaining prominence is the so-called three-wire generator, consisting of a standard direct-current generator designed for the maximum required electro-motive force and having collector rings connected to the armature winding like a two-phase rotary converter. The leads from these rings are connected to auto-transformers or balancing coils, the middle points of which are connected to the neutral wire. With no external devices whatever, the neutral wire is thus maintained at a voltage midway between the outside wires of the system (see Fig. 1). These generators may be operated in multiple with any standard three-wire system, whether it consists of two machines operated in series, a single-voltage generator with a balancing set, or a double-commutator generator. Any standard single-voltage system may be changed into a three-wire system by adding collector rings to the generator and using balancing coils to support the neutral wire.

The standard type of motor is used on this system. If only a small variation in speed is desired, as about two to one or less, only one voltage is used and the speed variation is secured entirely by changing the shunt-field current. If wider variations are required, it is preferable to use the two voltages of the three-wire system. It is necessary simply to make a 220-volt motor connected so that it may be operated on either 110 or 220 volts. The minimum speed is secured on the 110 or low-voltage circuit with full field strength. Any other speed less than double the minimum will be secured on the same circuit by decreasing the field current. All higher speeds are obtained on the 220-volt or high-voltage circuit in the same manner. Operated in this way the motor is started on the 110-volt circuit, having in series with the armature a resistance which is cut out for the first running notch. The speed is increased in successive steps by inserting resistances in the field circuit until the maximum 110-volt speed is reached. Then the controller changes the motor to the 220-volt circuit with a resistance in its armature circuit, and at the same time gives the motor a stronger field. The resistance in the armature circuit is used only in passing to the higher voltage, and is immediately cut out for the first running notch. For higher speeds, resistances are again inserted in the field circuit, as before, until the maximum desired speed is reached.

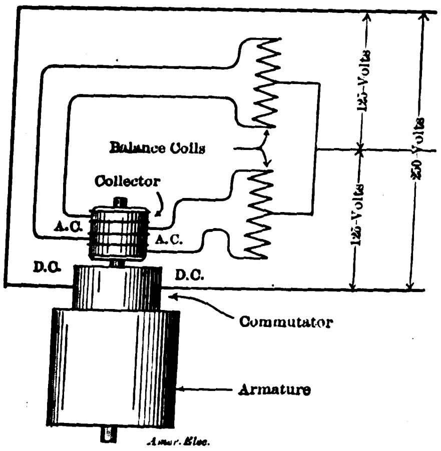


FIG. I.

In this manner a variation in speed of one to six is easily obtained. Greater variations may be obtained if desired, but are not to be recommended except in special cases, as the size and cost of the motor will be so great that larger variations than one to six are hardly to be recommended on any system. The size of motor is determined by the output at the lowest speed, so that unless the maximum speed is excessive the motor size will be very large for the output required if variations even of one to six are required.

The operation of motors on this system is most satisfactory. The fact that the speed is increased so much by weakening the field might lead some to think that the commutation would suffer, but such need not be the case. An example will demonstrate the truth of this statement. A certain machine requires a 5-h.p. motor to operate it with a speed variation of one to four, say, from 1,500 to 375 r.p.m. On the three-wire system this motor will be a standard 10-h.p. 220-volt motor operating normally at a speed of 750 r.p.m. Run with full field strength on the 110-volt circuit, it will develop 5 horse-power at about 375 r.p.m. On this circuit, which has only half its normal voltage, the motor will easily stand an increase of speed of 60 per cent. to 75 per cent., bringing the speed up to 600 or 650 r.p.m. When it is changed to the 220-volt circuit, it will have its full capacity of 10 horse-power at 750 r.p.m.; but only half load is required, and it will commutate this as easily at 1,500 r.p.m. as it would 10 horse-power at 750 r.p.m., because both field strength and armature current will be halved. From this it may be seen that when the motor is running at full armature current, the voltage is only one-half the normal voltage. When the motor is operating at full voltage, the armature current is only one-half the normal current. If speed variations of one to six are required, they can be secured by a very slight increase in the normal field strength of the motor.

The performance of the motor in speed regulation on the separate controller points is very good. As the lowest voltage used is 110 volts, the proportion of voltage lost in resistance of motor, brushes, armature, controller and wiring will be very much less than it would be if a minimum voltage of 60 volts were used, consequently the speed regulation will be much better. On an extremely slow-speed motor the resistances of the different parts of the circuit play a very important part in the speed regulation. Where a very low voltage is used the speed variation from no load to full load may be as much as 20 per cent. or 25 per cent.

The smoothness of operation in changing from one speed to the next is very noticeable. The field strength changes very gradually no matter how suddenly the field resistance is changed.

The efficiency of the motors, as well as of the entire system, is high. Operating on the low voltage, the motor is at all times running under full load conditions with the efficiency increasing as the speed increases, because the field current and core loss are decreased at the higher speeds. When operating at 220 volts at the minimum speed, the efficiency corresponds to the half-load efficiency of the standard motor. As the speed is increased, the copper loss in the armature remains constant and the field loss decreases so that unless the increased friction overbalances them, the efficiency will increase up to the maximum speed. This is in marked contrast to a motor operated on a system supplying a different armature voltage for each speed. To fill the requirements of the above case, a motor of the same weight but rated at 20 horse-power, 220 volts and 1,500 r.p.m. will be required. It will operate at a voltage of about 60 at minimum speed and will there require the normal full-load current to develop 5 horse-power. This would be double the current of the motor operated at 110 volts at the same speed; and while the copper loss in the armature and field and the core loss would be about the same as in the other motor, the loss in brushes would be doubled and the loss in controller and wiring very much greater. An increase in the speed will increase the core loss very rapidly, the field will remain constant and the copper loss in the armature will decrease. The efficiency of this motor may be explained by the statement that at the only time the motor is operating under its full-load armature current, it is running at 60 volts and the efficiency is necessarily low. At the maximum speed where the normal voltage of the motor is reached, it operates at only one-quarter load and consequently with a low efficiency. At no point on the curve does its efficiency equal that of the motor on the three-wire system.

The efficiency of the generating plant is also a maximum. The three-wire generator itself has the same efficiency as the standard direct-current generator of the same capacity. The losses in the balancing coils with 15 per cent. unbalanced load will not exceed one-quarter of one per cent. of the capacity of the generator.

The advantages of the system described in the foregoing may thus be summed up as follows: (1) Simplicity, not only in the generating plant, but in the transmission lines, motors and controller. (2) Efficiency in generating plant, transmission line and motor. (3) Economy in first cost of generating plant and transmission lines. (4) Constant speed regulation from no load to full load. (5) Smoothness of operation in changing from one speed to another.

These advantages are all easily apparent for work where the motor output is the same at all speeds. In such work the weights of the motors will be practically the same as those on the multi-voltage system. But it is recognized that in work where a constant torque over a wide range of speed is required the multi-voltage system has certain advantages. The motor required will be smaller, depending on the range of speed to be covered. However, for the small amount of such work that is to be done it is better to sacrifice a little in the size of a few motors than to introduce the complicated generating plant and the expensive transmission lines necessary for the multi-voltage system. Motors running on the three-wire system will meet all such requirements. It is only a question of making them large enough.

In cases where it is impracticable to have two voltages and a wide range of speed is necessary, a double commutator motor may be used with excellent results. This motor may be built with both ends of the armature wound for the same voltage, in which case they will be connected first in series, then in parallel, giving speed changes corresponding to the speed variations on the three-wire system.

[The foregoing is a paper read at a recent meeting of the American Institute of Electrical Engineers.]

AMERICAN PRACTICE IN ELECTRIC MOTOR CONSTRUCTION

The general features of direct-current motor construction have become so universally uniform in the United States that one might safely show a machine with a circular outline and radial magnet poles, a slotted drum-wound armature core and form-wound field-magnet and armature coils, and say that this represented American direct-current practice. So it does in the fundamental particulars specified, but, as all experienced motor builders and users know, the performance of a machine depends to a much less extent upon these features than upon such details as magnet-pole constructions, shape and arrangement of armature coils, quality of insulation, type of brush-holder, etc. When these are taken into consideration, the subject of motor construction broadens tremendously.

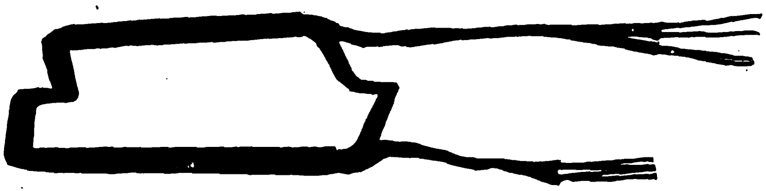


FIG. 1.—EICKEMEYER COIL.

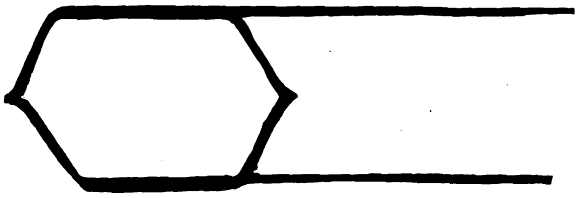


FIG. 2.—STRAIGHT-OUT COIL.

As intimated above, every representative motor builder in this country uses the circular magnet yoke with radial poles originated by Mr. C. E. L. Brown, the well-known Swiss engineer, and a slotted armature core; several manufacturers use also other forms of magnet, but the writer has not found any one who does *not* use the circular type. The slotted armature core appears to be the invariable rule, and with the exception of a very few special machines, the armature coils are always put only on the outside of the core—drum fashion. Three types of form-wound armature coils are used on multipolar machines—the Eickemeyer, "straight-out" or Fritsche and rectangular type. These are shown by Figs. 1, 2 and 3, respectively, and Figs. 42, 50 and 106 show the respective applications of these coils to armature cores. The rectangular and Eickemeyer coils as used by different designers vary somewhat in mechanical proportions, but the general features of each type remain practically the same throughout. In every case the coils are well insulated by either mica strips, or strips of leatherboard, pressboard or similar material laid on each side of the coil and covered by a wrapping of insulating tape. In the case of bipolar machines, which, as a rule, are built only in small sizes, the armature coils are wound directly into the slots of the core, the latter being, of course, insulated by means of troughs. The constructional features of direct-current motors which vary with different builders are illustrated by Figs. 7 to 110, inclusive.

Fig. 4 illustrates the invertible motor of the Akron Electrical Manufacturing Company. The magnet structure is of cast steel, and the field magnet coils are form-wound, taped, varnished and baked. The journal bracket consists of a ring fitted to the side of the yoke ring and having two arms terminating at a smaller ring in which is fitted a removable journal box. The box proper consists of a circular cast iron housing containing sleeves which are lined with anti-friction metal, and the arrangement is such that the motor may be mounted in any position without making any change in the position of either the journal bracket or the box. The brush holder studs are mounted on short lugs projecting radially from a ring, which is seated in a circular groove on the inner face of the journal bracket ring. This brush rig ring is easily adjusted by means of a screwdriver inserted in a small hole in the upper arm of the journal bracket, and when adjusted to the proper position, is clamped in that position by means of two small screws midway between the upper and lower pairs of bolts, which hold the journal bracket ring to the field magnet structure. The head of one of these screws may be seen in Fig. 4. The armature discs in machines larger than 2 horse-power are mounted on a ventilated sleeve; in the motors under 2 horse-power, the discs are mounted directly on the shaft and provided with ventilating openings near the shaft, which, when the core is assembled, form axial ducts through which air gains access to transverse ducts between the discs. The armature coils are of the straight-out type, heavily insulated individually.

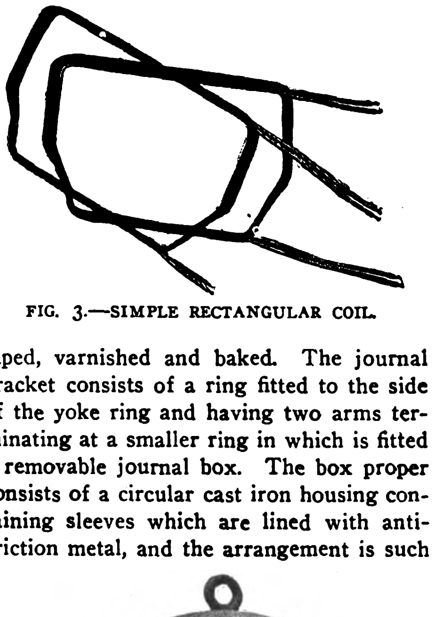


FIG. 3.—SIMPLE RECTANGULAR COIL.

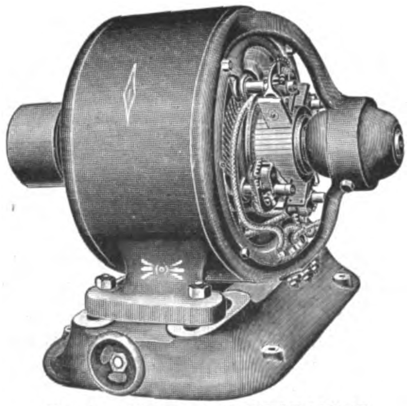


FIG. 4.—AKRON INVERTIBLE MOTOR.

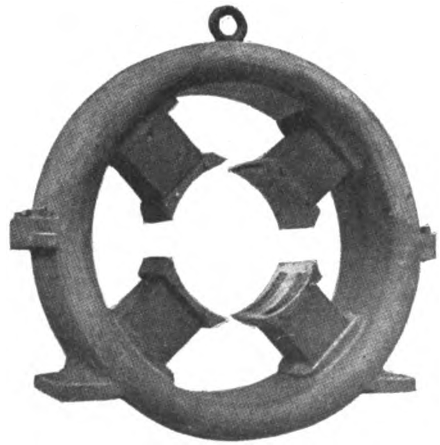


FIG. 5.—AKRON FIELD MAGNET.

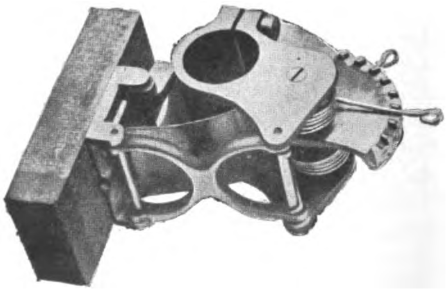


FIG. 6.—AKRON BRUSH-HOLDER.

The field magnet structure of larger Akron machines is illustrated by Fig. 5. The yoke ring is made of cast iron in a single piece for machines under 35 horse-power, and divided horizontally, as shown in the engraving, for machines of 35 horse-power and above. The magnet poles are built up of rectangular sheets of soft steel and cast-welded into the yoke ring. Cast steel pole-shoes are provided, of the shape shown in the engraving. The field magnet coils of this type of machine are wound on substantial metal spools which are heavily insulated with pressboard and mica before the coils are wound into them. The outer surface of each coil is protected by a layer of heavy cord. The field magnet is bolted to a base of substantially rectangular outline with rounded corners, the base being cast in one piece with the two journal pedestals. (This general type of construction is illustrated by Fig. 27, which, however, shows the machine of another manufacturer.)

The armature coils are of the straight-out type like those of the smaller machines, and are insulated throughout their entire length before being placed on the core. The commutator segments of all Akron machines are drop-forged to gauge and are of the overhanging type; that is to say, each end of the segment projects over the periphery of the clamping ring which holds the structure together. The Akron brush holder is illustrated by Fig. 6, which shows it to be of the parallel motion type. The brush is solidly bolted to a plate which is linked by two arms to the stationary part of the holder in such manner as to feed the brush always at the same angle toward the commutator. The tension springs are coiled about stout pins in the holder, and the manner of adjustment is made clear by the engraving. A flexible leaf conductor is used to connect the brush plate with the stationary part of the holder, so that the pivots are not relied upon to carry current. The brushes are of such cross-section that the current density at the contact does not exceed 30 amperes per square inch, and in most cases the density is below this figure. The brush holders of the pedestal type of machine are mounted on a ring which is seated in brackets on the side of the yoke ring, so as to be adjusted circularly, this adjustment being accomplished by means of a hand-wheel and screw.

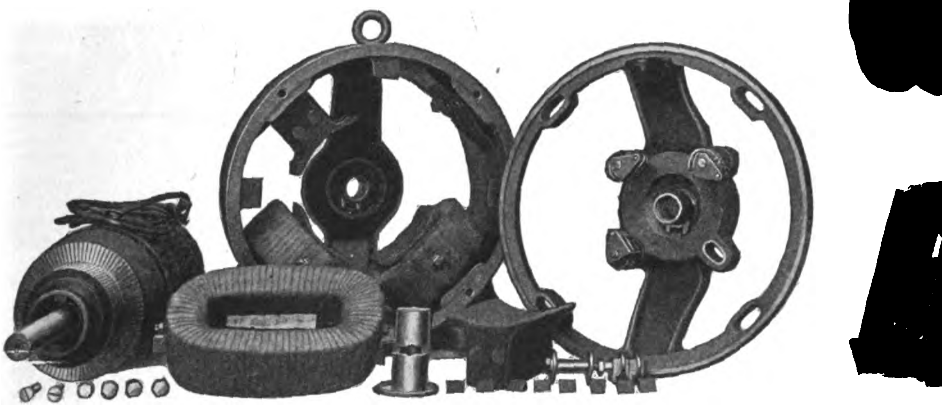


FIG. 7.—DISMANTLED BULLOCK MOTOR.

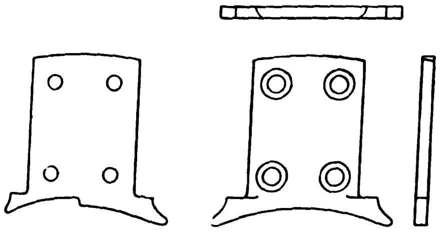


FIG. 8.—BULLOCK DETAILS.—FIG. 9.

The Bullock Manufacturing Company uses the circular type of magnet yoke exclusively. Fig. 7 shows a 15-h.p. motor dismantled, and Figs. 8, 9, 10 and 11 illustrate respectively a magnet pole stamping, cheek piece, axial and transverse sections and the armature construction of this machine. As the engravings indicate, the field-magnet poles are made up of stampings of sheet steel, the outline of which is shown by Fig. 8. These stampings are assembled with the longer pole-tips turned first one way and then the other, so that the outline of the finished pole is symmetrical on both sides, but the pole-face contains only one-half the amount of metal axially that is contained in the body of the pole. The object of this construction is to saturate the pole-face and thereby check field distortion. The laminations are flanked by cast-iron cheeks of the shape shown by Fig. 9, and the whole structure is bolted together. The arc at the upper end of the pole-block is of the same radius as that to which the pole seats are bored out in the yoke ring, and the magnet poles are secured to the ring by means of counter-sunk machine bolts. The bearings are carried by a bracket cast integrally with a ring, as shown in Fig. 7, when the ordinary type of motor is desired. For complete enclosure the journal bracket castings have solid walls, forming cup-shaped brackets.

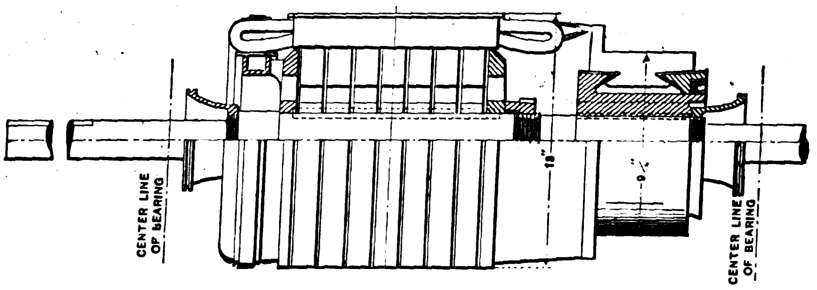


FIG. 11.—BULLOCK ARMATURE.

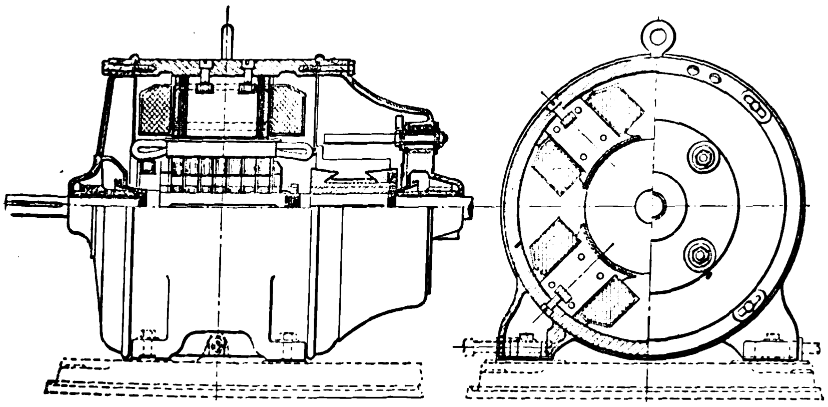


FIG. 10.—SEMI-SECTIONAL ELEVATIONS OF BULLOCK MOTOR.

The armature winding of this type of machine is of the straight-out form illustrated by Fig. 2. The armature coils, except in the two smaller sizes, are held in the slots by wedges of hard, thoroughly dried wood, which are driven into notches in the teeth near the periphery of the armature. The brush-holder is a modification of the reaction type, and is illustrated by Fig. 12, which shows both the front and back of a group of five holders and brushes. The chief divergence from the familiar Baylis form of holder consists of the application of a guiding bolt attached to the brush and sliding in a slot in the holder, and a conducting strap bolted to the upper end of the brush, which affords a path of constant conductivity between the holder and the brush, regardless of the pressure with which the brush is forced against the holder by the feeding finger. This type of machine, while suitable, of course, for any class of service in which a standard stationary motor is used, is built especially for service in mills, factories, machine shops, etc. The Bullock Company also builds the

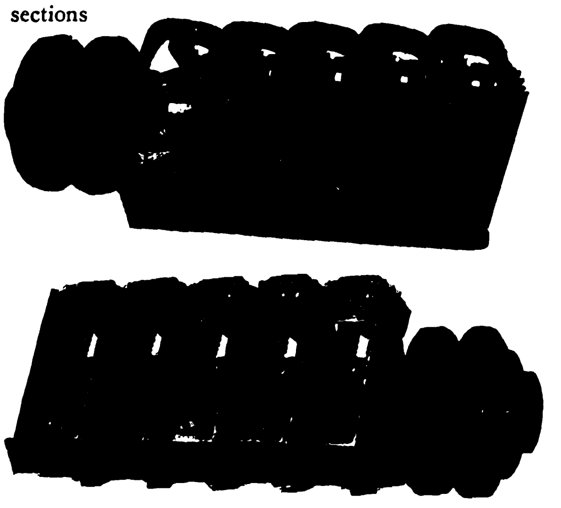


FIG. 12.—BRUSH-HOLDER.

FIG. 13.—FIELD COIL.

familiar open type of machine, with a circular yoke and pedestal bearings, in which the same type of field-magnet pole is used as that just described. The magnet coils are machine-wound and covered by a winding of Sampson cord on the outside, as illustrated by Fig. 13. The armature coils are of the straight-out type, but are modified in shape so that instead of projecting horizontally beyond the core at the back end, they lie nearer to the shaft, as illustrated in Fig. 14. The same type of brush-holder is used on this machine as on the other. The commutators of both types of machine are built up of cold-rolled copper bars of absolutely uniform thickness.

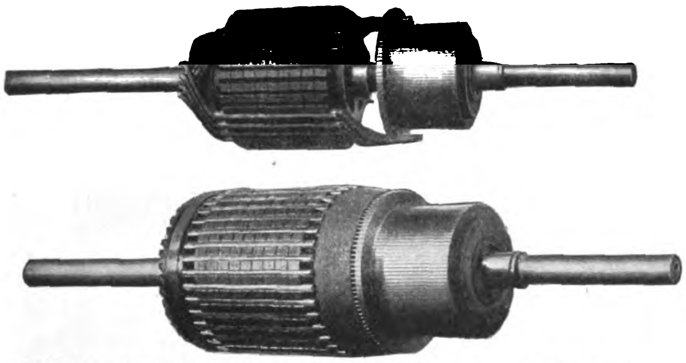


FIG. 14.—PARTLY-WOUND AND COMPLETE BULLOCK ARMATURES.

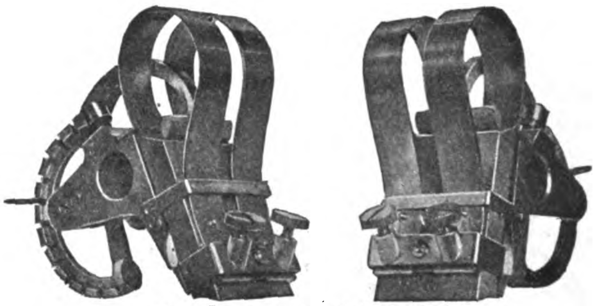


FIG. 18.—C. & C. BRUSH-HOLDERS.

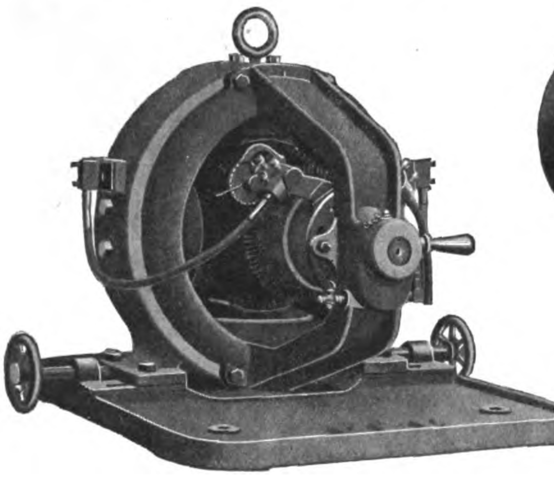


FIG. 15.—STANDARD C. & C. MOTOR.

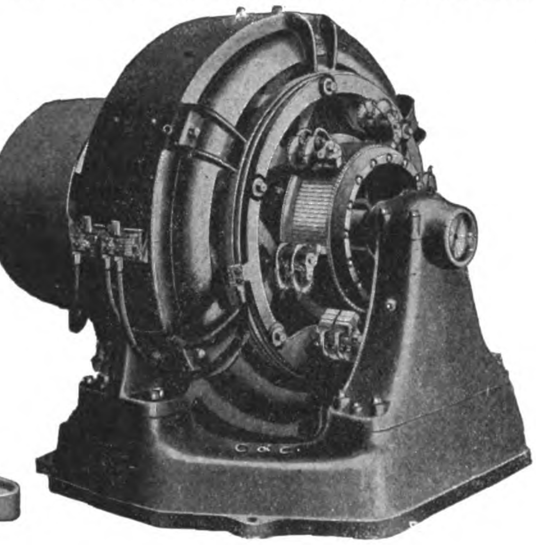


FIG. 17.—C. & C. MOTOR.

In machines of 65 horse-power and less, the armature discs are mounted directly on the shaft; machines larger than 65 horsepower are provided with a spider on which the discs are mounted. The armature core is ventilated, of course, in accordance with general modern practice, by spaces left between the two neighboring discs at intervals along the core, axially, and by axial ducts through the core near the shaft.

The C. & C. Electric Company builds several types of machine, which include both bipolar and multipolar construction. Fig. 15 illustrates the standard type, which is of the four-pole variety with the magnet poles bolted to the yoke ring. The method of mounting the bearing is so clearly shown by the engraving that comment is unnecessary. The yoke ring is of cast steel. Fig. 16 illustrates the factory type of machine built by the C. & C. Company. In this type the magnet cores and yoke ring are cast integrally of steel, and the poles are provided with removable shoes bolted to their inner ends. The brackets carrying the journals are of cast-iron, of course, bolted on as the engraving indicates. When a completely-enclosed motor is desired, the openings shown in the engraving are closed by means of thin cast-iron shields which fit snugly over them. The field-magnet coils are wound on metal spools. The armature discs are built up directly on the shaft and the slots are lined with troughs of tough insulating material which, of course, reinforces the insulation that has been applied to the coils before they are put on the core. Larger sizes of C. & C. motors are of the form shown by Fig. 17, and provided with six poles. The magnet poles are bolted to a cast-steel yoke ring, which is divided horizontally, and the poles are cast with projecting tips of the usual shape. As the illustration indicates, the brush-holders are mounted on a ring bolted to a similar ring on the side of the field-magnet structure. In all of the C. & C. machines either hard-drawn or rolled commutator segments are used, and the reinforced reaction brush-holder shown by Fig. 18 is used. Besides the machines here shown, the C. & C. Company continues the manufacture of its bipolar motors put on the market a number of years ago.

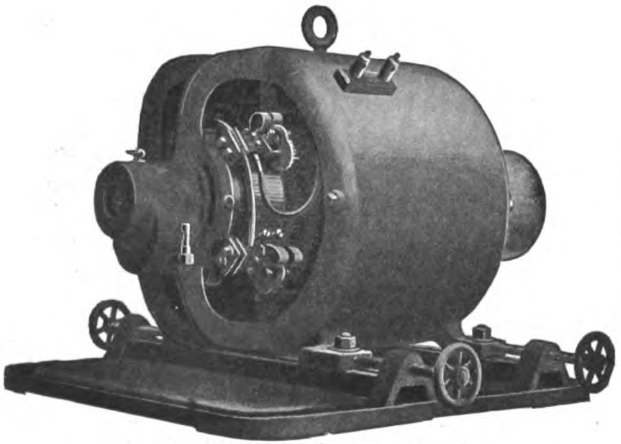
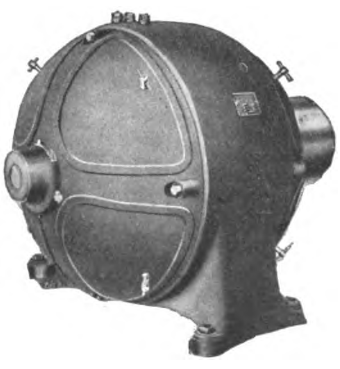


FIG. 16.—TYPE "F. P.," C. & C. MOTOR.



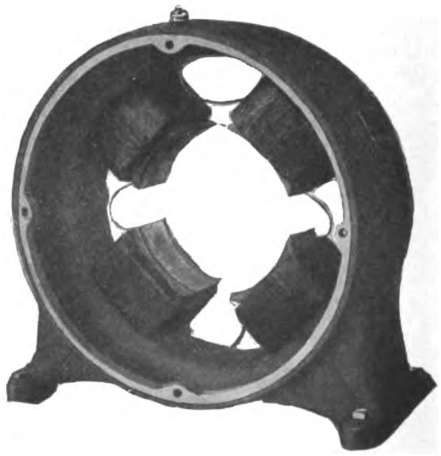


FIG. 19.—CHRISTENSEN MOTOR.—FIG. 20.

One of the most recent accessions to the ranks of motor builders is the Christensen Engineering Company, of Milwaukee, whose machine is illustrated by Fig. 19. The yoke ring of the machine, shown by Fig. 20, is a steel casting, to which the poles are bolted. A noteworthy feature of the yoke ring is the disposition of the metal; it will be noticed upon close inspection of the engraving that that portion of the ring beyond the planes of the magnet-pole edges, or sides, is not relied upon for a magnetic path, but is made only thick enough to give it the mechanical strength necessary to hold the journal brackets. The portion of the ring lying in the same plane with the magnet poles is much thicker than is usually the case, so that there is ample cross-section for the magnetic lines between adjacent poles without their going outside of the straight path within the plane of the poles. The poles themselves are built up of laminations clamped between cheeks, as indicated in Fig. 21, and the coils are form-wound, heavily taped and provided with block terminals secured to the coil so as to relieve the ends of the wire from all mechanical strain; Fig. 22 illustrates this construction. The armature coil is of a form between the rectangular and the straight-out types, and is illustrated by Fig. 23. The armature core discs are reannealed after being punched, and coated with an insulating compound. They are built up directly on the shaft in all except the largest sizes, and provided with ventilating openings near the shaft, through which air can reach the ventilating ducts between the discs. The brush-holder is of the box type, and the rods are mounted on arms projecting from a ring which is fitted to one end of the journal box in the well-known manner; Fig. 24 shows a complete brush rigging. The brushes are fed through the boxes by means of flat springs coiled about the brush-holder studs and provided with tension adjustment.

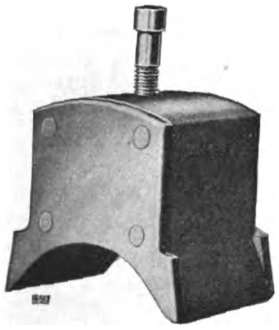


FIG. 21.—CHRISTENSEN MAGNET POLE.

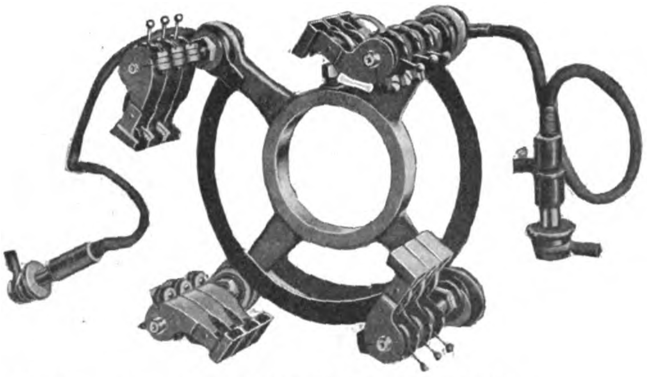


FIG. 24.—CHRISTENSEN BRUSH RIGGING.

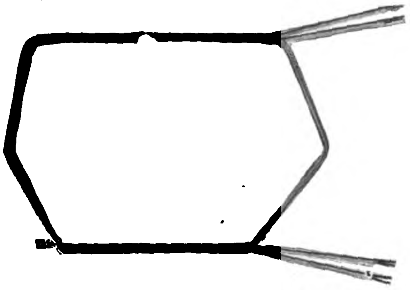


FIG. 23.—CHRISTENSEN ARMATURE COIL.

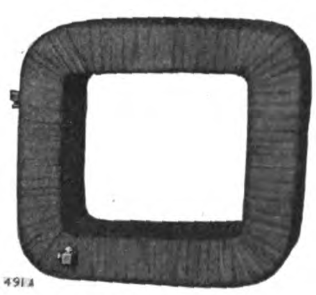


FIG. 22.—FIELD COIL.

The Commercial Electric Company builds three types of motors, which are illustrated by Figs. 25, 26 and 27. Fig. 25 represents what is probably the most widely used of the three types. The yoke ring and magnet poles are of cast steel and the magnet coils are form-wound and individually insulated. The type illustrated by Fig. 26, as the engraving shows, is semi-enclosed, and may be made completely enclosed by the addition of shields fitted to the openings in the journal brackets. The form shown by Fig. 27 requires no explanation of the field magnet construction beyond the statement that the yoke ring and magnet poles are cast integrally of steel, and the poles are provided with removable shoes. The poles are circular in cross-section and the coils are, of course, form-wound and are protected by a layer of cord on the outside. As the engraving shows, the pedestals for the bearings are cast in one piece with the base, so that it is impossible for them to get out of alignment with each other. All three types of machine are provided with the straight-out form of armature coil, shown by Fig. 2, and held in place by means of binding wires. The armature discs are mounted on a spider, and the fitting between the shaft and the spider is such that the shaft may be readily removed should any accident require its being displaced by a new one. The

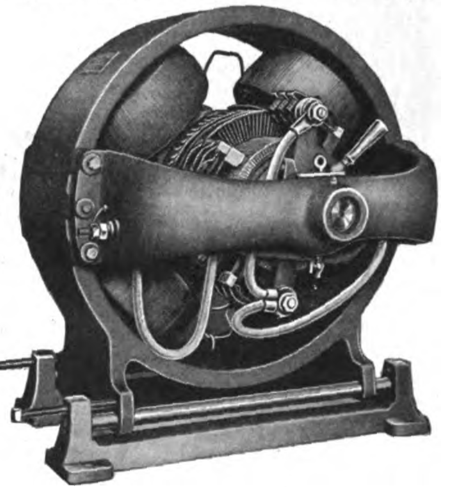


FIG. 25.—"COMMERCIAL" MOTOR.

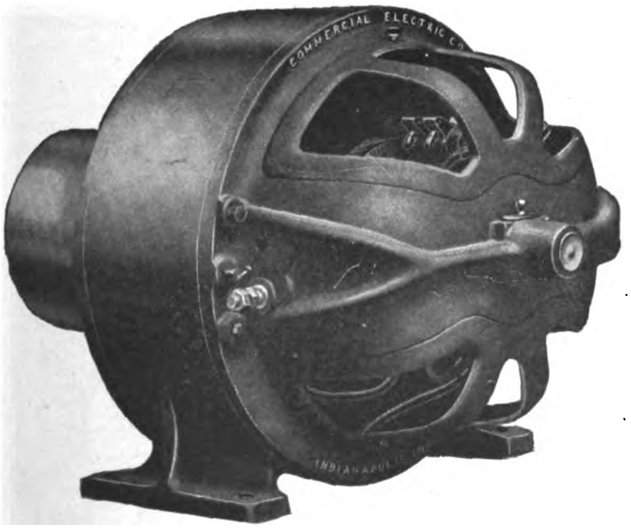


FIG. 26.—"COMMERCIAL" MOTOR.

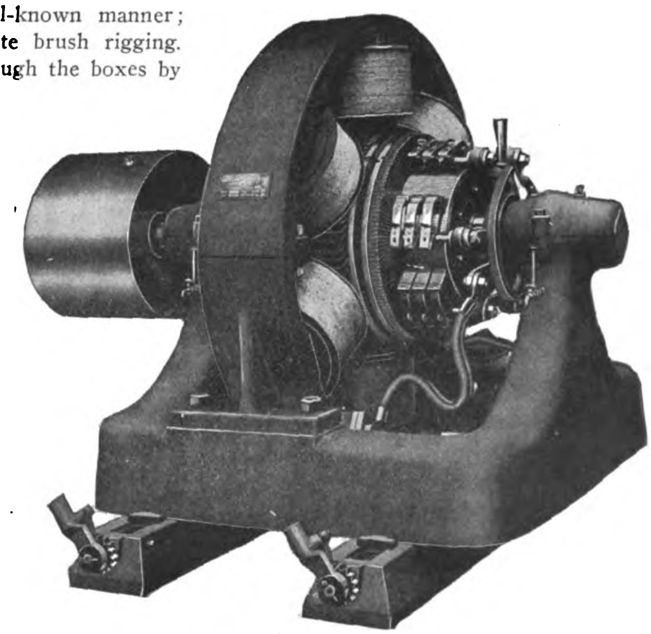


FIG. 27.—"COMMERCIAL" MOTOR.

commutator segments are rolled to gauge, so that they are of uniform thickness.

Fig. 28 illustrates the standard motor of the Crocker-Wheeler Company for sizes of 3 to 9 horse-power inclusive, which the engraving shows to be a machine of extremely compact and graceful design. The field-magnet frame and journal brackets are of cast-iron, molded in a single piece, the journal brackets being bored to the same radius as the pole-faces to form the seats for the short journal pedestals. The magnet poles are of round wrought-iron cast-welded into the frame and provided with removable shoes of laminated steel. In sizes of 10 horse-power and above, a separate base, of the type illustrated in Fig. 29, is used. The magnet poles are of round wrought iron like those in the smaller machine, but the pole-shoes are of cast-iron and fitted to the magnet poles in the manner indicated in Fig. 30. The magnet frame is split horizontally, and the lugs by which it is bolted together are located on the inside so that the smoothness of the external contour is not violated. Inspection of both Figs. 28 and 30 will show that the yoke rings are provided with a shrouding web on each side, which serves the double purpose of stiffening the ring without involving the use of an excessive quantity of metal and of protecting to a considerable extent the field-magnet coils. These coils are wound on cylindrical bobbins and covered with a layer of cord for protection. The armature winding is of the straight-out type shown by Fig. 2, the coils being form-wound and individually insulated, of course. The brushes are clamped solidly in box-shaped holders, and these are attached to the stationary part of the brush-holder rig by means of copper strips built up of thin leaf to give flexibility. Fig. 31 shows a single brush-holder and a group of three on a single rod. In the smaller sizes of machine the brush-holder rods are mounted on the usual rocker-arm, and in larger sizes the holders are mounted on arms secured to a ringshaped structure, as illustrated in Fig. 32, the outer ring of this structure being held by the four lugs shown bolted to the field-magnet frame in Fig. 30. It will be noticed that the faces of these lugs are grooved, and these grooves correspond to projections on the raised portions of the external ring in Fig. 32, so that no other provision is required to hold the brush-holder rig in position axially.

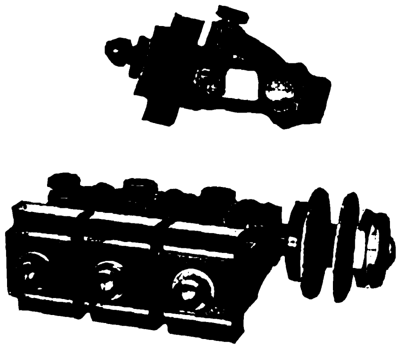


FIG. 31.—CROCKER-WHEELER BRUSH-HOLDERS.

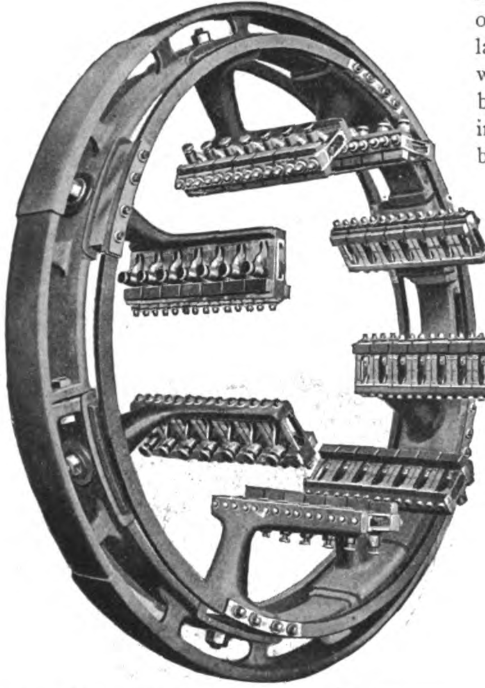


FIG. 32.—CROCKER-WHEELER BRUSH RIGGING.

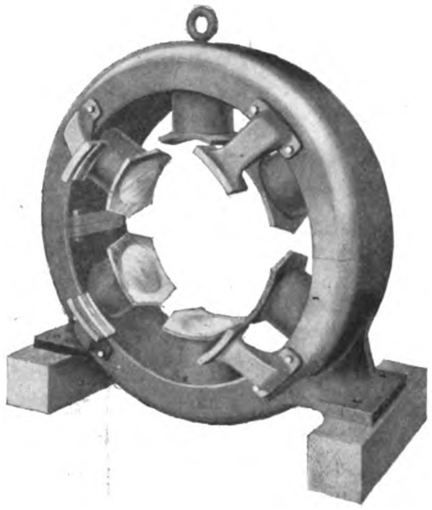


FIG. 30.—CROCKER-WHEELER FIELD MAGNET.

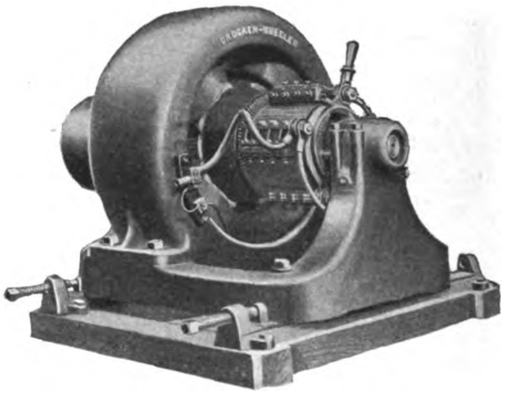


FIG. 29.—CROCKER-WHEELER MOTOR.

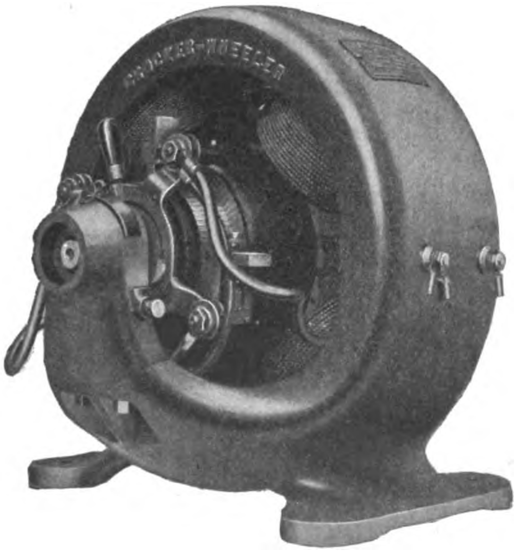


FIG. 28.—CROCKER-WHEELER MOTOR.

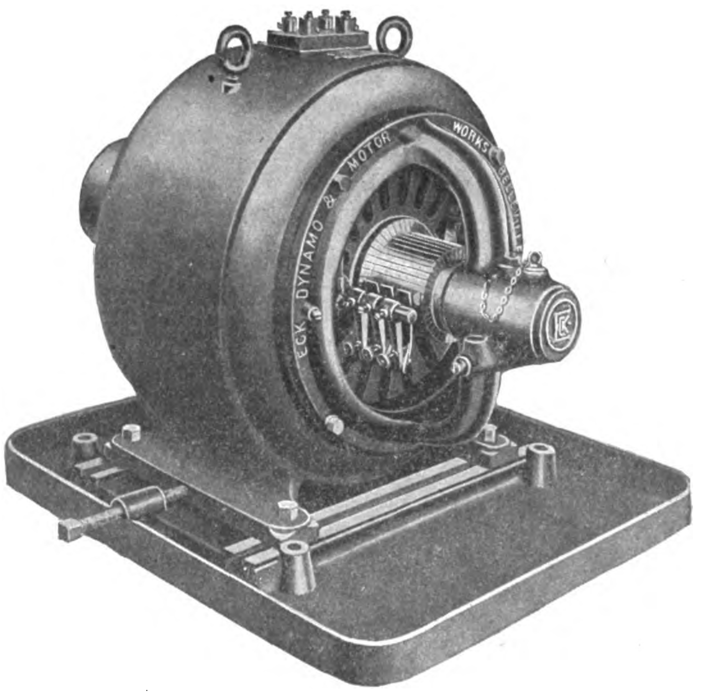


FIG. 33.—ECK MOTOR.

The motors of the Eck Dynamo & Motor Works, although bipolar, have all of the constructional features which have been generally adopted in modern multipolar machines, with the exception, of course, of the number of poles; and the external appearance of the machine (see Fig. 33) is very similar to that of the four-pole motors. The yoke ring is of cast-iron and in sizes of 1 horse-power and over, the magnet poles are of round wrought-iron, cast-welded into the ring and provided with removable pole shoes. After the armature coils are wound into the slots, the complete armature is baked to remove moisture, then dipped in armature varnish and baked again. The armature shaft, as Fig. 34 clearly shows, is considerably smaller where the pulley is fitted on than it is in the bearings; the object of this construction is to permit the shaft to be turned down slightly where it works in the bearing, should this ever be made necessary. The construction of the bearings is of the standard modern form, so that extraneous material cannot readily find entrance, but human ingenuity has never been able to devise a bearing into which objectionable matter is not likely to be admitted through ignorance or carelessness on the part of the attendants. Another advantage that this construction gives is that the shaft can be slipped out of the journal sleeve regardless of burrs on the portion where the pulley is located. Fig. 35 illustrates a brush and brush-holder, both of which are unusual in design. The brush is a small block of carbon with the rear end rounded to fit the concave surface of the brush-holder. A shallow hole, *a*, is drilled in the back of the brush for the reception of a pin, *b*, riveted to the holder, the function of this pin being to prevent the brush from sliding laterally out of position. The brush is pressed against the commutator by means of a flat tempered steel spring, *f*, tension adjustment being provided in the screw, *e*. In order to relieve the spring from serving as a conductor, copper strips, *d*, are provided, which connect the solid part of the rigging with the block which holds the carbon. The holders are mounted on rods in the usual fashion and the rods are secured to a ring which fits in a groove on the inner face of the journal bracket ring. The brush-holder ring is also provided with a slotted web which serves to partly enclose the motor frame at that end of the machine. The construction is clearly shown in Fig. 34, the brush rigging being shown in the foreground. Fig. 36 illustrates the baby Eck machine built in sizes of 1-6 horse-power and under. The yoke ring and poles are cast in a single piece and the openings on each side of the frame are just large enough to permit the armature to be inserted and withdrawn. When the journal brackets are in position, the machine is practically enclosed, the only openings being those through which the brushes feed to the commutator.

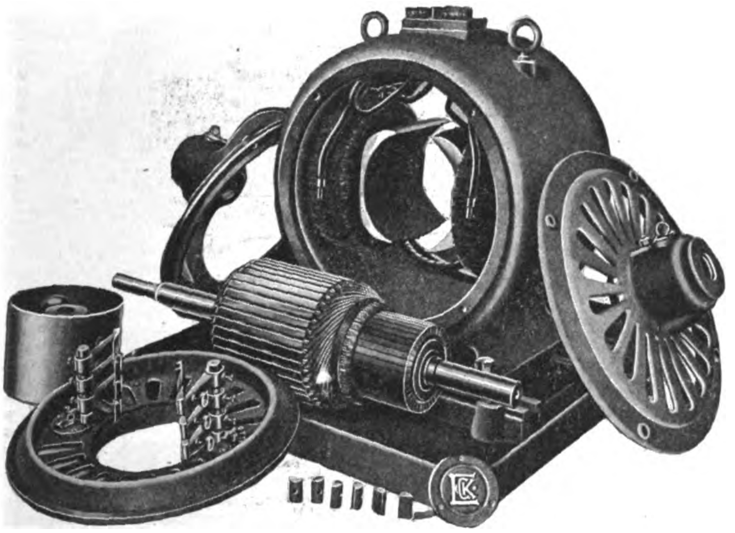


FIG. 34.—DISASSEMBLED ECK MOTOR.

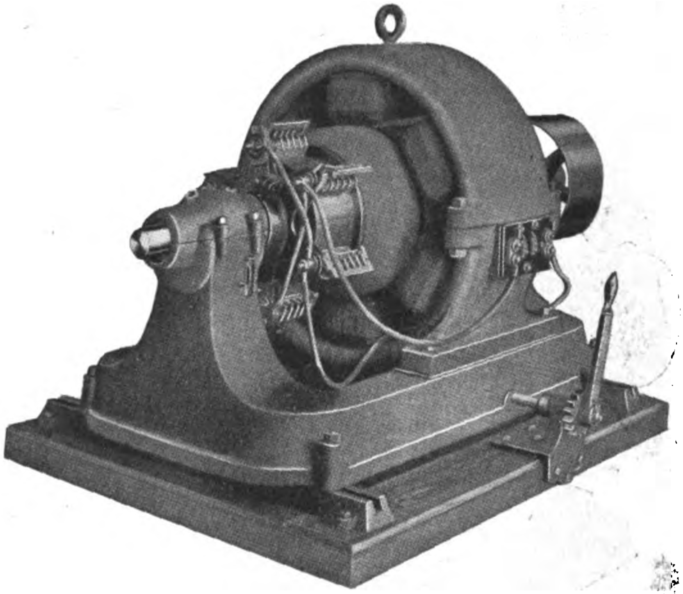


FIG. 39.—ELEKTRON MOTOR.

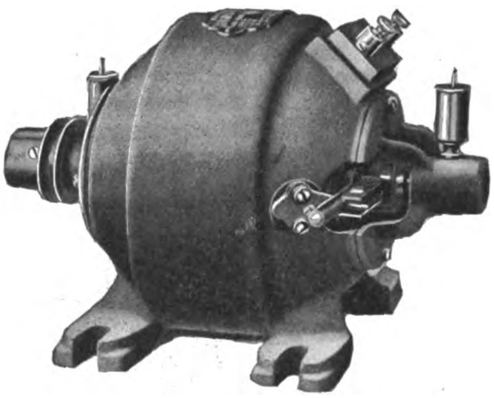


FIG. 36.—ECK MOTOR.

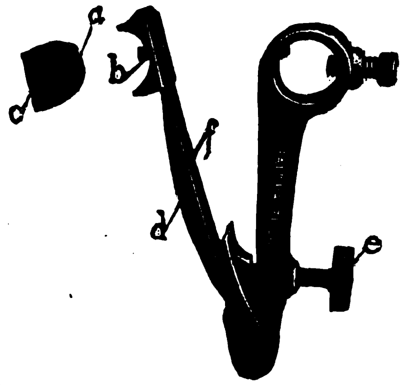


FIG. 35.—ECK BRUSH AND BRUSH-HOLDER.

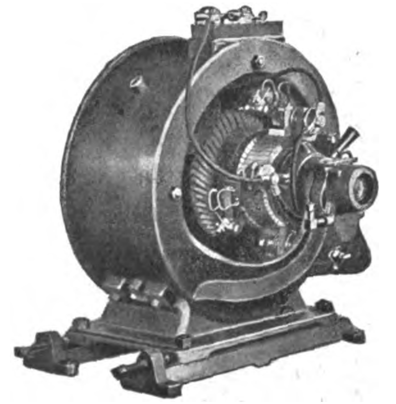


FIG. 37.—ELECTRO DYNAMIC MOTOR.

Fig. 37 illustrates the motor built by the Electro Dynamic Company in sizes up to 5 horse-power; larger sizes are of the pedestal type with an octagonal field-magnet yoke. The yoke ring is of cast steel, and the magnet poles are also of cast steel, but bolted to the ring. The poles are circular in cross-section and cast with polar extensions or tips. The arrangement of the journal bracket is shown clearly by Fig. 37 and needs no description. The field-magnet coils are wound on spools and protected by cording. The armature coils are of the Eickemeyer type, shown by Fig. 1.

Fig. 38 illustrates the well-known Perret motor, built by the Elektron Manufacturing Company and constituting a class by itself so far as field-magnet construction is concerned. It is a six-pole machine and the magnet structure consists of three entirely separate bipolar magnets located equidistantly around the armature and held in place by the framework shown in the engraving. The magnets are built up of sheet steel, and the magnet coils are wound on bobbins located directly upon the magnet cores, only three coils being used. The coil

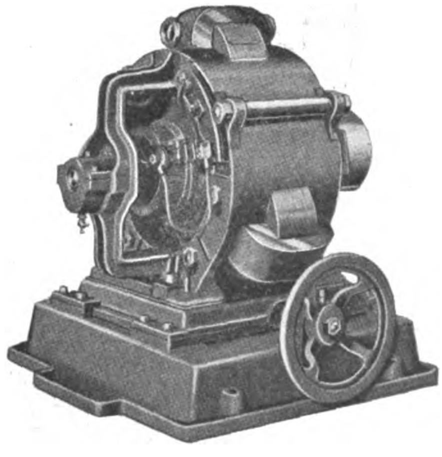


FIG. 38.—ELEKTRON MOTOR.

is located on the part that would be the yoke of an ordinary horse-shoe magnet. Fig. 39 illustrates a more recent type of Elektron motor which is built in larger sizes than the older type shown by Fig. 38. As the engraving clearly indicates, the base and journal pedestals are cast in a single piece, similar to one or two frames of other builders which have already been described. The magnet poles and yoke ring are integral, the field-magnet coils being slipped on the poles and held in place by brackets. The armatures of both of the Elektron types are of the usual slotted construction, with form-wound and individually insulated coils. The commutator segments are drop-forged, and the brushes and holders are a modification of the reaction type.

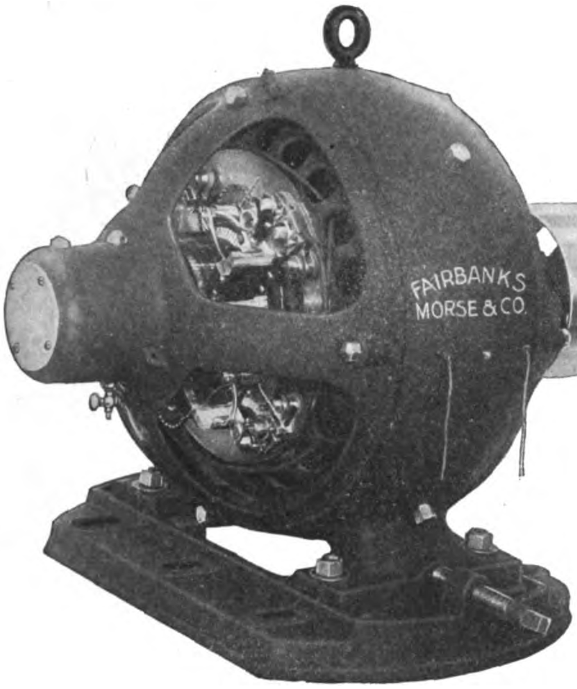


FIG. 40.—FAIRBANKS-MORSE MOTOR.

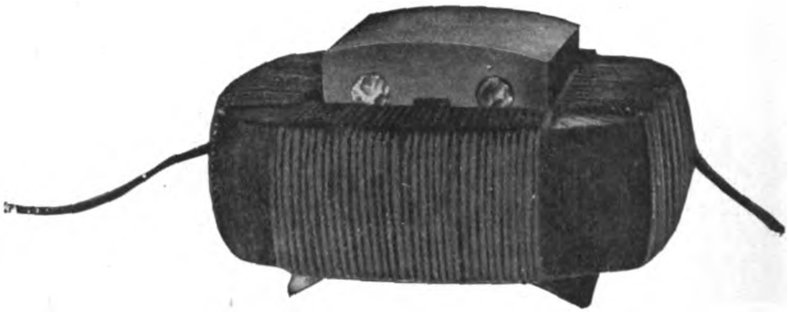


FIG. 41.—FIELD-MAGNET POLE AND COIL.

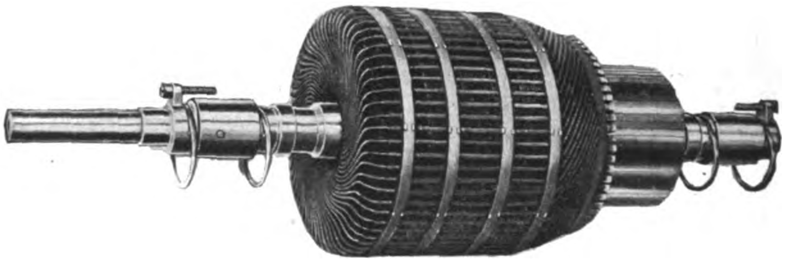


FIG. 42.—ARMATURE OF FAIRBANKS-MORSE MOTOR.

The motor illustrated by Fig. 40 is built by Fairbanks, Morse & Co., who recently acquired the business and good will of the Three Rivers Electric Company. The field-magnet poles are built up of sheet steel and clamped together between malleable iron cheeks, as indicated in Fig. 41. The upper end of the pole structure is machined to a radius concentric with the armature and ground to fit accurately a seat of the same radius on the interior of the yoke ring. The machine is converted into the semi-enclosed type by the application of gratings to the openings around the commutator, and is made completely enclosed by putting on metal shields of the proper shape to complete the spherical contour of the frame. The armature coils are of the Eickemeyer type shown by Fig. 1, the complete armature being shown by Fig. 42. It will be noted from an inspection of this engraving that the journal sleeves are provided each with a lug and screw for attachment to the journal housing. The sleeves are, therefore, adjustable in and out, so as to allow the armature to take up the natural position in the center of the magnetic field without forcing the shoulder of the shaft up against the end of the sleeve. The commutator segments are drop-forged, and the brush-holders are of the swivel type illustrated by Fig. 43. As the engraving shows, the brush is clamped in the box and the latter is pivoted on a stem around which is coiled the tension spring. No rocker-arm is used, the brush-holder being bolted to a ring fitted to a circular seat on the journal bracket casting.

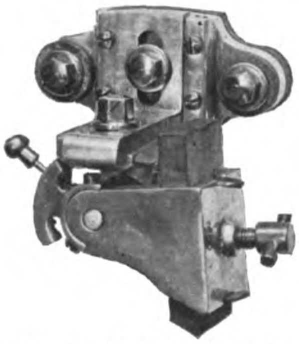


FIG. 43.—FAIRBANKS-MORSE BRUSH HOLDER.

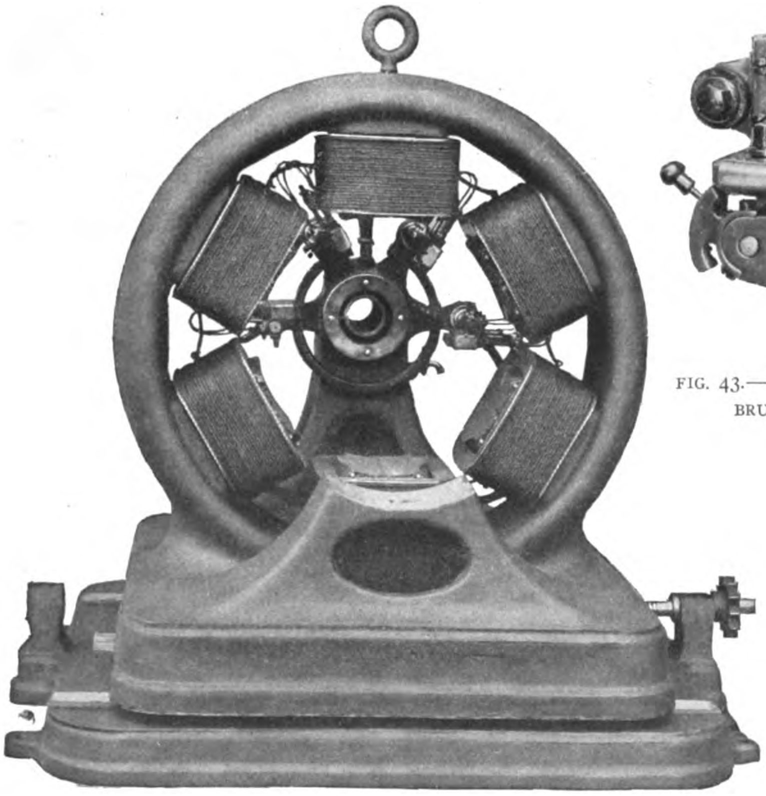


FIG. 45.—FT. WAYNE MOTOR.

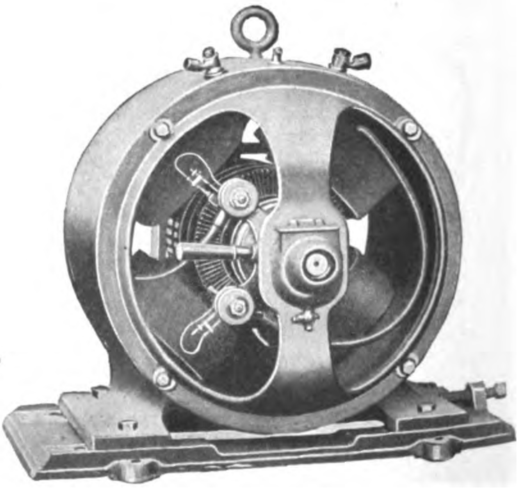


FIG. 44.—FT. WAYNE MOTOR.

The small motor of the Fort Wayne Electrical Works is illustrated by Fig. 44. The yoke ring and magnet poles are cast in a single piece, and no pole-shoes are used, the corners of the pole-faces being bevelled off to concentrate the magnetic field. The magnet poles are rectangular in cross-section and are slotted parallel with the shaft, from the pole-face about half way up, toward the yoke. The style of machine shown by Fig. 45 is built by the Fort Wayne Electric Works in medium and large sizes. The yoke ring is of cast-iron with the magnet poles cast-welded into it. The poles are built up of laminations of the shape indicated in Fig. 46, and provided with a cast-iron pole-shoe of the shape shown at the bottom of the same engraving. As Fig. 45 indicates, one of the pedestals is removable, being fitted to a curved seat which is machined concentric to the armature. The other pedestal of the machine is cast integrally with the base and yoke ring.

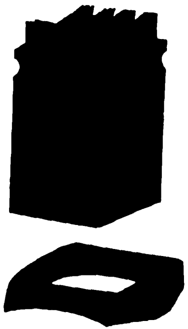


FIG. 46.

The armature winding in all of the Fort Wayne machines is of the straight-out type, and the commutator segments are rolled to gauge. The brush-holder is of the box type, of unusually compact construction, and the brush is fed through it by a helical spring. Fig. 47 shows a complete holder and brush, and also shows a brush and its tension spring separate from the holder. The stem about which the spring is coiled is mounted in a socket riveted to the upper end of the brush, as shown in the engraving, and a flexible "pig-tail" connects the brush permanently with the holder.

The small motors of the General Electric Company are built in sizes up to 2 horse-power with bipolar field magnets, and in sizes of 2 horse-power and over with multipolar magnets. Fig. 48 shows the bipolar machine. The casting which forms the exterior is merely a casing and does not constitute a part of the magnetic circuit. The field-magnet yoke and poles are of laminated iron and only one pole is provided with a winding. The poles are in a vertical plane, the one carrying the field coil being at the bottom, as the location of the armature shaft would indicate. The casing is open at the top for the removal of the field magnet, the opening being normally covered by a cap of thin cast-iron. The journal boxes are cast with flanges fitted to circular openings in the sides of the casing, which openings are just large enough to allow the removal of the armature endwise. The armature winding is of the Eickemeyer type, and the brushes are fed radially in stationary boxes. The multipolar machine is illustrated by Fig. 49. The yoke ring is of cast steel, and the magnet poles are laminated and bolted to the ring. The journal bracket comprises a ring with four curved radial arms centering at the journal housing, the whole structure being bolted to the yoke ring of the machine. The armature winding of this machine is of the straight-out type; Fig. 50, which has been referred to as a typical armature of this class, was made from a photograph of a General Electric armature. The winding is held in place by binding wires. The brush-holders are of the box type, the brushes being fed by fingers under the influence of coiled springs. In General Electric motors of larger sizes the yoke ring, base and journal pedestals are all cast in a single piece, as in the case of some of the machines already described. The field-magnet poles in these larger sizes have a circular cross-section and are cast of steel with extended pole tips. The armature is of the standard slotted construction and wound with straight-out coils. The brush-holders are of the box type, but the brushes are fed by long, flat springs, as indicated in Fig. 51.

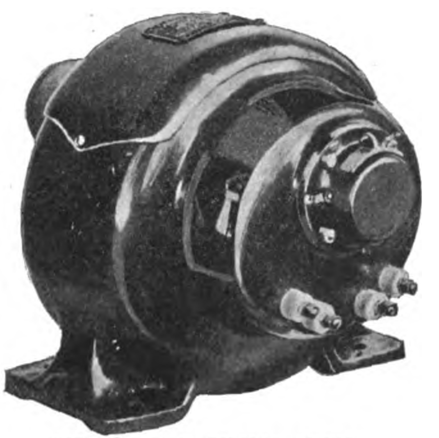


FIG. 48.—G. E. BIPOLAR MOTOR.

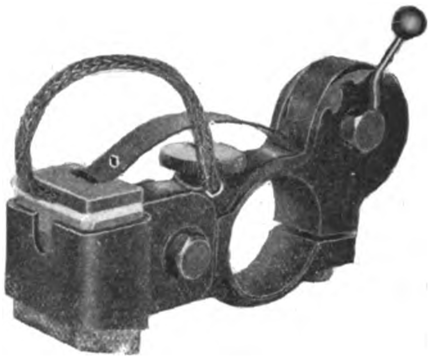


FIG. 51.—G. E. BRUSH HOLDER.

The Paragon multipolar motor, built by the General Incandescent Arc Light Company, is illustrated in its newest form by Fig. 52. The yoke ring is of cast-iron and provided with tapering flanges or bonnets to which the journal-bracket rings are secured; the shape of the latter is clearly shown by the illustration. The field-magnet poles are built up of sheet steel, stamped to the shapes shown in Fig. 53. It will be noticed that the stampings shown on each side of the complete pole block are not exactly alike, the one on the right-hand side having a rectangular slot punched near its upper end and a channel punched between this slot and the outside of the stamping. In assembling the stampings, a sufficient number of this shape are grouped together near one side of the pole block to form a cubical pocket in which a square nut is lodged as the building-up process goes along. There are two groups of these slotted plates, so that each pole block contains, when finished, two nuts for the reception of the holding-in bolts. The upper end of the completed pole is curved to the

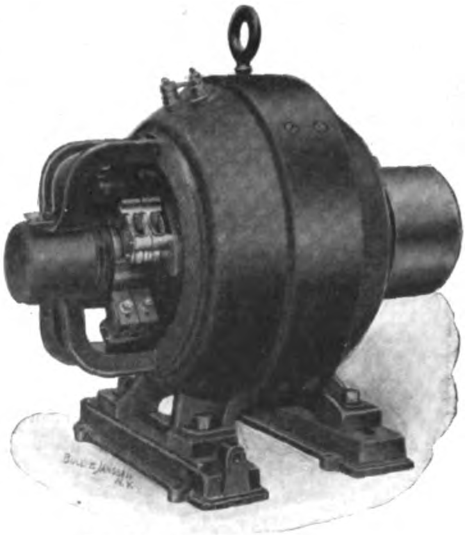


FIG. 52.—PARAGON MOTOR.

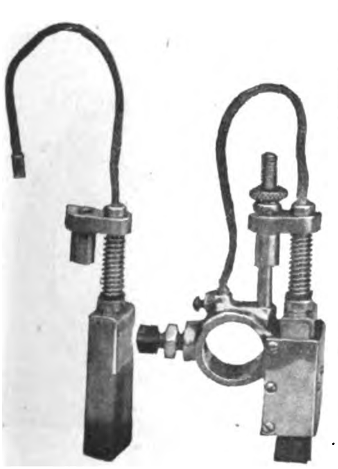


FIG. 47.—FT. WAYNE BRUSH AND HOLDER.

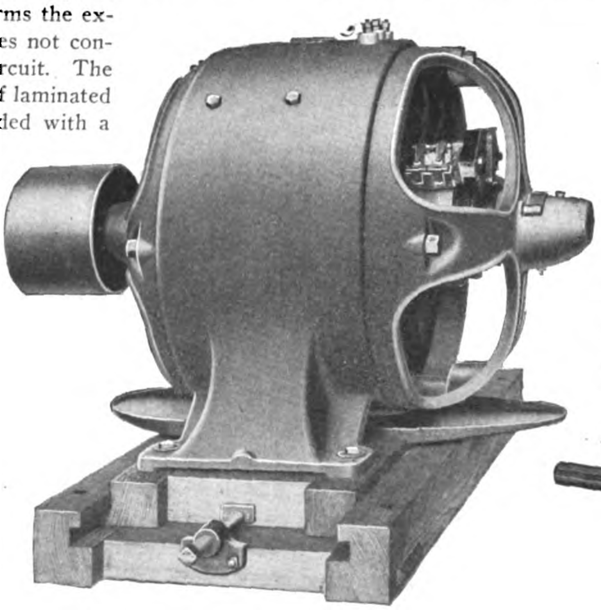


FIG. 49.—G. E. MULTIPOLAR MOTOR.

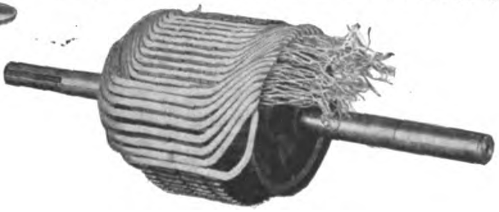


FIG. 50.—G. E. ARMATURE.

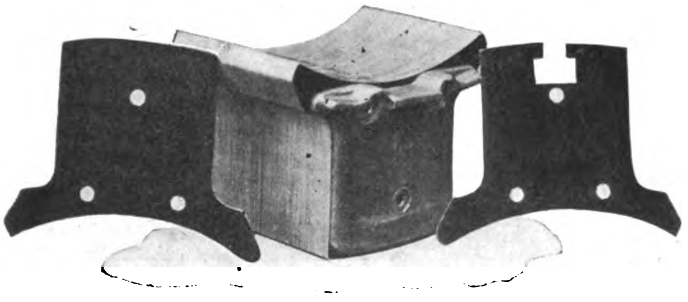


FIG. 53.—PARAGON POLE-PIECE AND LAMINATIONS.

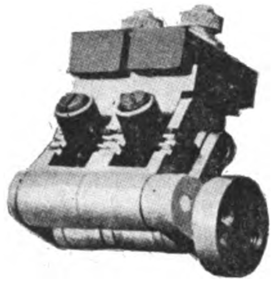


FIG. 54.—BRUSH HOLDER.

arc of a circle concentric to the shaft, and similarly curved seats are machined on the interior of the pole ring. Close inspection of the stamping will show that one pole-tip is shorter than the other; in assembling the plates the longer pole-tip is turned first to one side and then to the other, with the result that the tips of the completed pole have alternate sheets and air spaces in the direction parallel with the shaft. In operation, therefore, the pole-tips are saturated and the crowding of magnetic flux into the leading pole is thereby greatly reduced. The armature winding is of the straight-out type; the brush-holders (see Fig. 54) are of the parallel motion type, the brushes being bolted solidly to the faces of plates which are linked by parallel arms to two stationary pivots. The General Incandescent Arc Light Company also builds the well-known bipolar iron-clad Paragon motor, with which this line of machines was originally started.

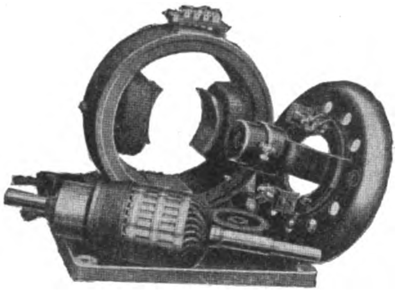


FIG. 55.—HOLTZER-CABOT MOTOR.

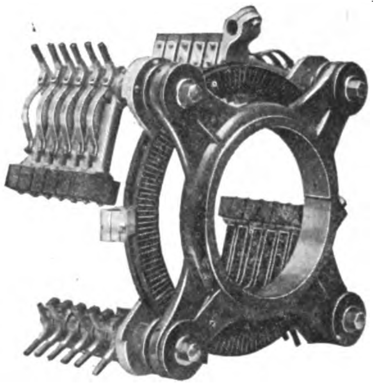


FIG. 57.—BRUSH RIG.

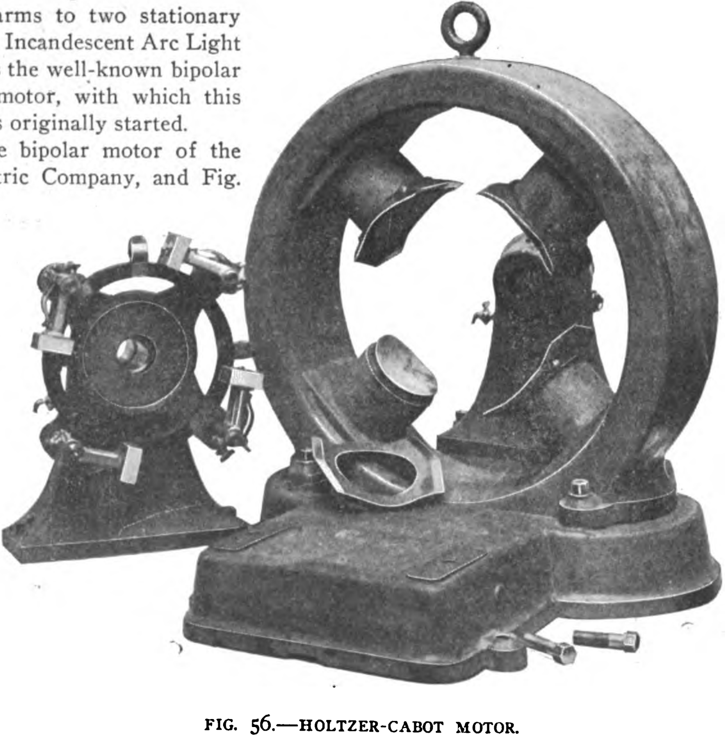


FIG. 56.—HOLTZER-CABOT MOTOR.

Fig. 55 shows the bipolar motor of the Holtzer-Cabot Electric Company, and Fig. 56 illustrates the multipolar machine of that company, as built for ordinary service. The field-magnet yokes of both machines are of cast iron, and in the smaller machine the magnet poles are laminated and bolted to the yoke ring. The armature winding is of the straight-out type, the coils being held in the slots by means of hard-wood strips in the small machines, and by phosphor-bronze binding wires in machines of 5 horse-power and larger. The brush-holders are of the pivoted type, the brushes being bolted to the ends of arms which are pivoted on the brush-holder rod. The brush-holder rods are mounted on a ring which is fitted in a recess in the face of the journal-bracket casting, as shown clearly in Fig. 55. In the multipolar machine, the field-magnet cores are of round wrought-iron cast-welded into the yoke ring and provided with malleable iron pole-shoes in the smaller sizes, and cast-iron shoes in the larger ones. The field-magnet coils are form-wound, of course, and before being taped, they are baked in order to remove all moisture. The coils are then soaked in insulating varnish while still warm, after which they are dried and covered with several layers of tape reinforced with mica and micanite. The coils are then baked for 24 hours at a temperature of 225 degrees Fahr. The armature winding is of the straight-out type, as in the smallest machines. The commutator segments are drop-forged in the small machines and rolled in the large ones. The brush-holders in the larger machines are of the same general type as those on the smaller ones; the brush-holder rods, however, are mounted in arms projecting from a ring fitted on the end of the journal box in the well-known fashion. Fig. 57 illustrates the brush rig of a 60-h.p. motor.

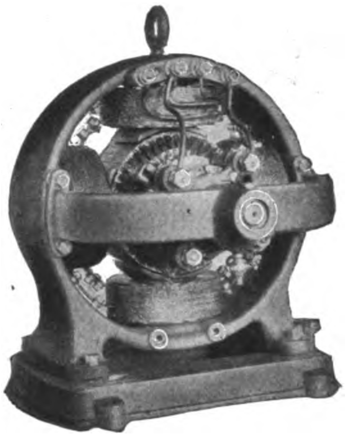


FIG. 58.—KEYSTONE MOTOR.

Fig. 58 illustrates the type of motor built by the Keystone Electric Company in small and medium sizes, and Fig. 59 shows the type of field-magnet frame used in the larger sizes of machine. The magnet poles of the smaller machine are of cast steel, of the shape illustrated by Fig. 60, and are provided with form-wound coils. The journal bracket is an ordinary two-armed bracket, no ring being used. The armature winding is of the Eickemeyer type, and the brush-holders are of the reaction type, shown by Fig. 61. The magnet poles of the larger machine are also of cast steel, with the polar extensions cast integrally with the cores, but are of circular cross-section. The yoke ring is of cast-iron with a light shrouding web around each edge. The armature winding of this machine is also of the Eickemeyer type.

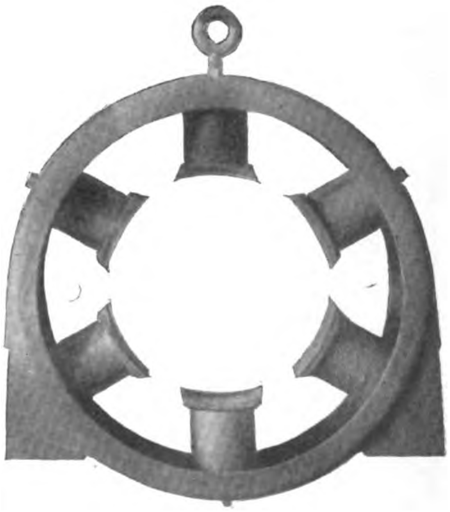


FIG. 59.—KEYSTONE FIELD MAGNET.

Fig. 62 illustrates the bipolar machine built by the Lincoln Electric Company, the mechanical construction of which is obvious from the engraving. The multipolar machine of this company is illustrated by Fig.

63. The yoke ring and one-half of each journal pedestal are cast of iron in a single piece, and the magnet poles are laminated and cast-welded into the yoke ring. Reaction brushes and brush-holders are used.

Fig. 64 illustrates the motor of the Maxwell M. Mayer Electric Company, which is bipolar in sizes up to and including 5 horse-power, and four-polar in larger sizes. The magnet-yoke ring is of cast iron, with round steel cores cast-welded into it; the inner ends of the magnet cores are provided with removable pole-shoes. The field-magnet coils are wound on fibre spools, varnished, baked and taped as usual. The brush-holders are of the reaction type.

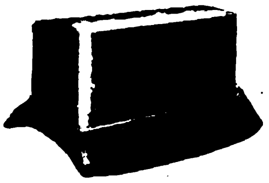


FIG. 60.—KEYSTONE MAGNET POLE.

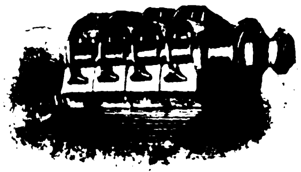


FIG. 61.—KEYSTONE BRUSH HOLDER.

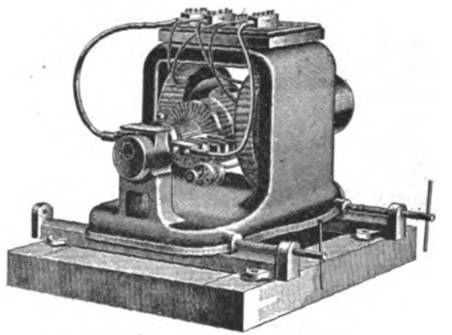


FIG. 62.—LINCOLN MOTOR.

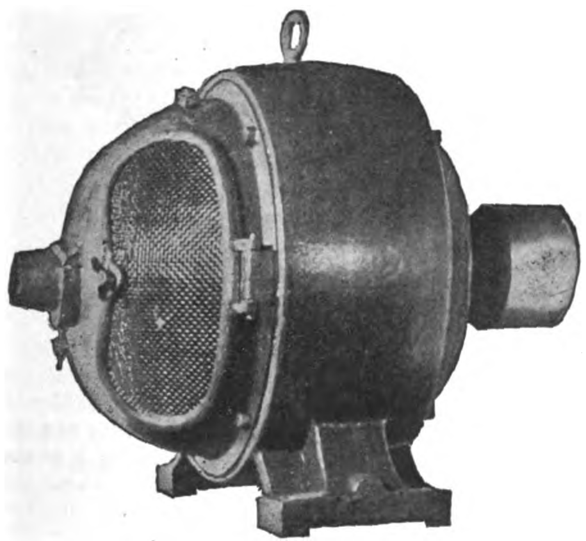


FIG. 64.—MAYER MULTIPOLAR MOTOR.

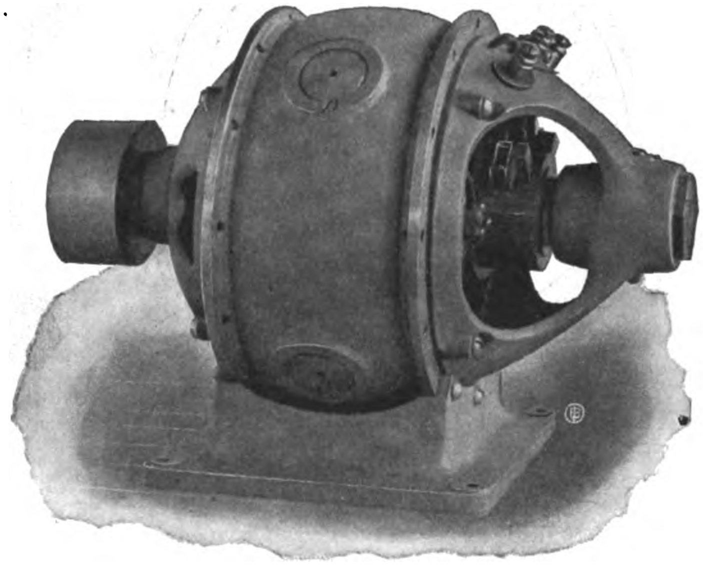


FIG. 67.—JENNEY MULTIPOLAR MOTOR.

The Mechanical Appliance Company builds the compact little machine illustrated by Fig. 65. The magnet frame is of steel, with the poles and yoke ring cast integrally. The poles are slotted from the yoke ring down to a point near the pole-face, as illustrated by Fig. 66, this construction serving to reduce the weight of the machine and also tending to reduce field distortion. The field magnet coils are form wound, taped and baked. The armature winding is of the straight-out type and the brush-holders are of the pivoted type, with the brushes bolted to the faces of the holders. The form and arrangement of the journal bracket casting is clearly shown by Fig. 65.

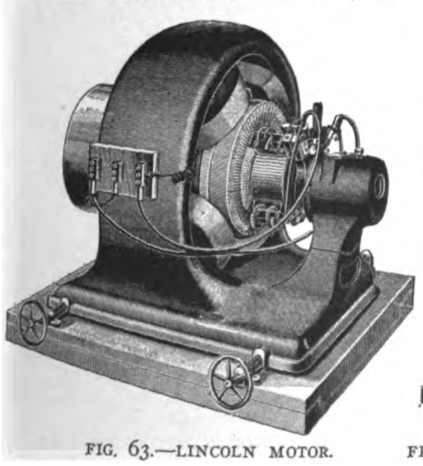


FIG. 63.—LINCOLN MOTOR.

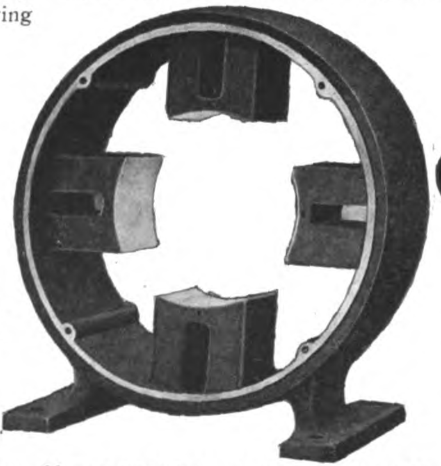


FIG. 66.—MECHANICAL APPLIANCE MAGNET.

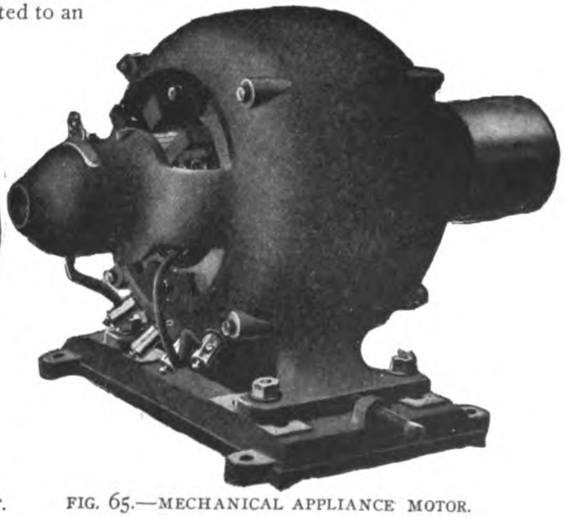


FIG. 65.—MECHANICAL APPLIANCE MOTOR.

Fig. 67 illustrates the "Universal" motor of the Jenney Electric Manufacturing Company. The field magnet cores of this machine are of circular cross-section and set in holes in the yoke ring. The cores are of wrought-iron and the yoke ring is of cast-iron. The field-magnet coils are wound on metal spools with brass flanges, except in the very small sizes, the coils of which are wound in forms and taped. The armature winding is of the straight-out type, and the brush-holders are of the pivoted type. The brush-holder rods are mounted in a ring fitted to an inner flange of the journal bracket casting. The shape of the latter is clearly shown by the engraving; it is faced and turned to fit flanges on the yoke ring somewhat similar to the flanges on a steam engine cylinder.

Fig. 68 illustrates the field-magnet structure of the motor built in moderate sizes by the Northern Electrical Manufacturing Company. The yoke ring is of cast steel and the magnet poles are of the same material, but cast separately and bolted in. They are of circular cross-section with rectangular pole-faces, as the engraving shows. The magnet coils are form-wound and are of substantially square cross-section. The coils are heavily taped, varnished and baked, and are banded on the outside with a layer of cord for mechanical protection.

The journal-bracket is of the ring and arm type and is shown by Fig. 69. In larger motors the yoke ring shown by Fig. 70 is used. This is bored out smooth all the way around and the poles are bolted to the ring at the proper intervals. The magnet coils are form wound, but they are secured solidly to the magnet poles before the latter are put in position in the yoke. Fig. 71 illustrates a pole with compound windings. The yoke ring is bolted to a base of substantially rectangular outline, and individual journal pedestals are used, bolted to the base. The armature winding of all sizes is of the straight-out type, each coil being insulated throughout its length before going on the core. The commutator segments are drop-forged, with the grain or "flow" in the direction of length. The brush-holders are of the pivoted type and are illustrated by Fig. 72; the engraving is practically self-explanatory. In the small self-contained machines, the brush-holder rods are mounted on the usual form of rocker arm; in the larger sizes they are attached to a circular rigging mounted on the side of the yoke ring.

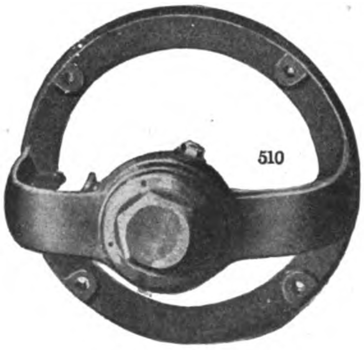


FIG. 69.

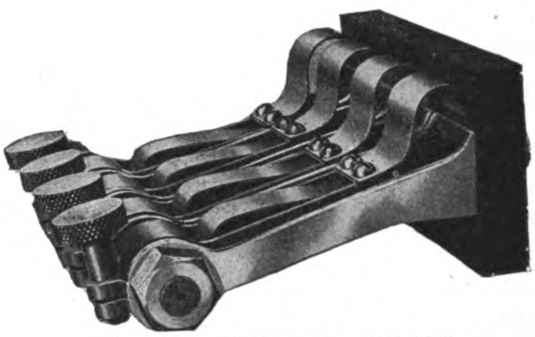


FIG. 72.—NORTHERN BRUSH HOLDER.

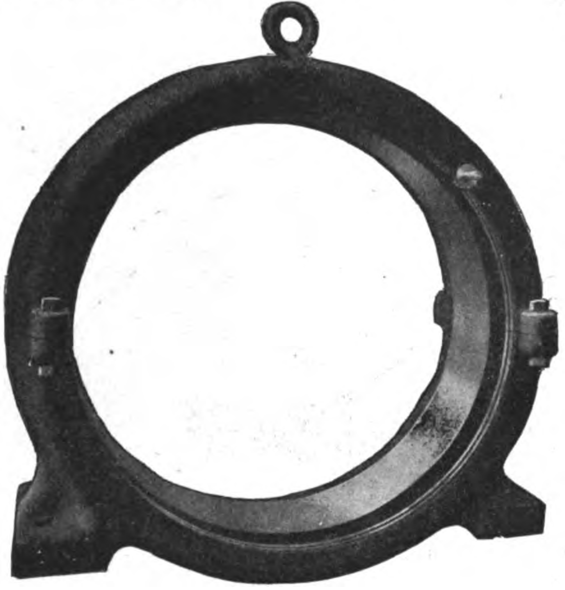


FIG. 70.—NORTHERN YOKE.

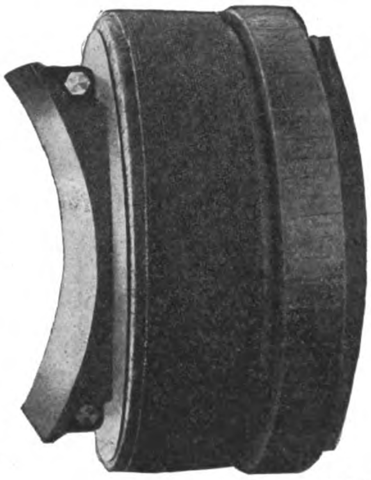


FIG. 71.—NORTHERN MAGNET POLE.

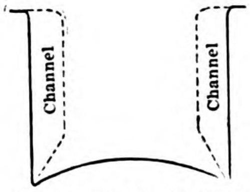


FIG. 74.—PHOENIX MAGNET POLE.

The Phœnix Electric Manufacturing Company builds the machine shown by Fig. 73 in sizes up to 20 horse-power at medium speeds. Above this size the construction of the yoke ring, base and pedestals is generally similar to that shown by Fig. 27. In all sizes, except very large machines, the yoke ring is made of cast iron, with steel magnet poles cast-welded into it. These poles are of the rather unusual shape indicated by Fig. 74. The cross-section of the pole is substantially rectangular, with rounded corners, but channels are cored into each side of the pole, as indicated by the dotted lines in Fig. 74. These serve the triple purpose of reducing the weight of the material, affording ventilation to the field magnet coil, and forming a thin pole-tip which is normally saturated. The field coils are form-wound, varnished, taped and baked, and are held in position by means of brackets bolted to the yoke ring, separate pole-shoes not being used. In the smaller machine illustrated by Fig. 73, the journal bracket is cast integrally with a flat ring, which is machined to fit snugly in a recess in the edge of the yoke ring, so that the outer face of the bracket ring is flush with the extreme outer edges of the yoke ring. The bracket ring is made sufficiently deep radially to protect the field-magnet coils and give the machine virtually a semi-enclosed structure. In the larger sizes the journal pedestals are bolted to the base.

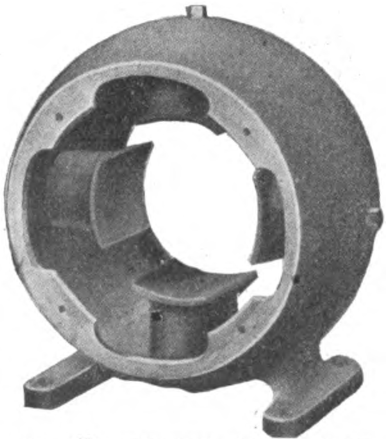


FIG. 68.—NORTHERN FIELD-MAGNET.

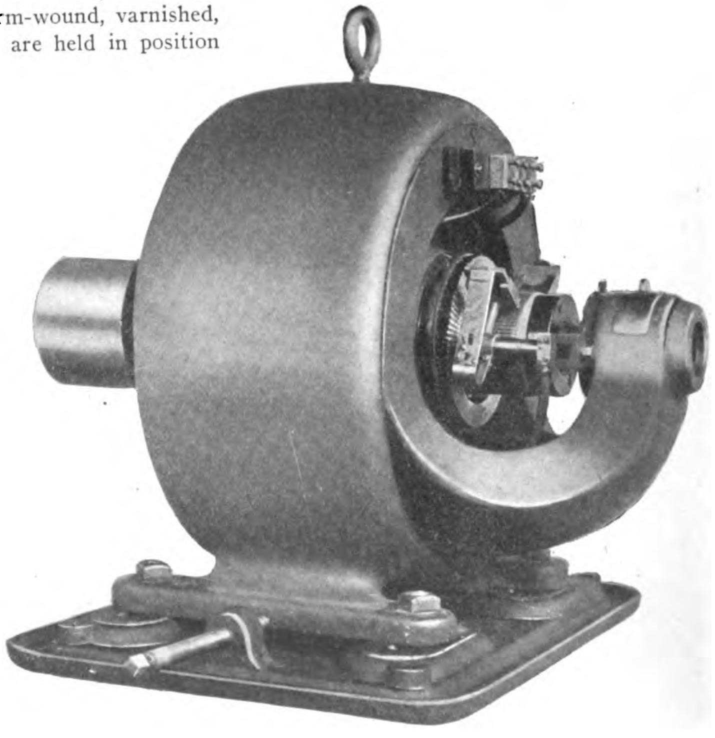


FIG. 73.—PHOENIX MOTOR.

The straight-out type of armature coil is used in all sizes, and the winding is connected up for two paths in the smaller machines and four in the larger machines, all of them having four poles. The winding for the larger machines, while giving four paths through the armature and requiring four sets of brushes around the commutator, is not the ordinary lap winding, but is of an unusual type arranged so that each path through the armature is composed of conductors which lie in equal numbers under each pole of the field-magnet, so that the e.m.f. from brush to brush is exactly the same all the way around, regardless of variations in the strength of different poles or differences in the air gaps. The type of brush-holder shown in Fig. 73 is no longer used, the new type comprising a grooved plate on which the brush is fed toward the commutator at an angle of about 22½° from a straight radial line, the brush being pressed firmly against the holder plate by means of a flat phosphor-bronze spring and fed toward the commutator by means of a finger actuated by an adjustable helical spring.

Fig. 76 illustrates the bipolar motor built by the Quaker City Electric Company, and Fig. 75 shows the enclosed multipolar type of machine built by that company. In both cases the field-magnet yoke and poles are cast in a single piece, of open hearth steel. The field-magnet coils are form-wound and insulated in the usual modern way. The remaining features of mechanical construction are clearly shown by the engravings. The armature coils of both the multipolar and the bipolar machines are wound directly into the core slots, which, of course, are heavily insulated before the winding is done. The brush-holders are of the box type, the brushes being fed radially by means of helical springs attached to the ends of a cross-bar, which straddles the upper end of the brush at right angles to the brush-holder rod.

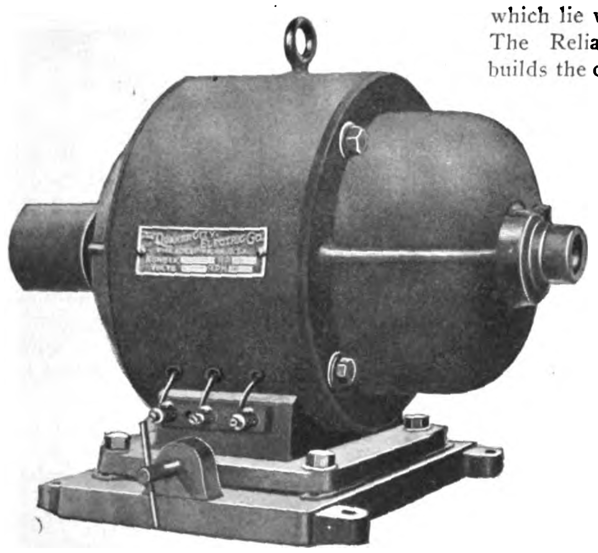


FIG. 75.—QUAKER CITY MOTOR.

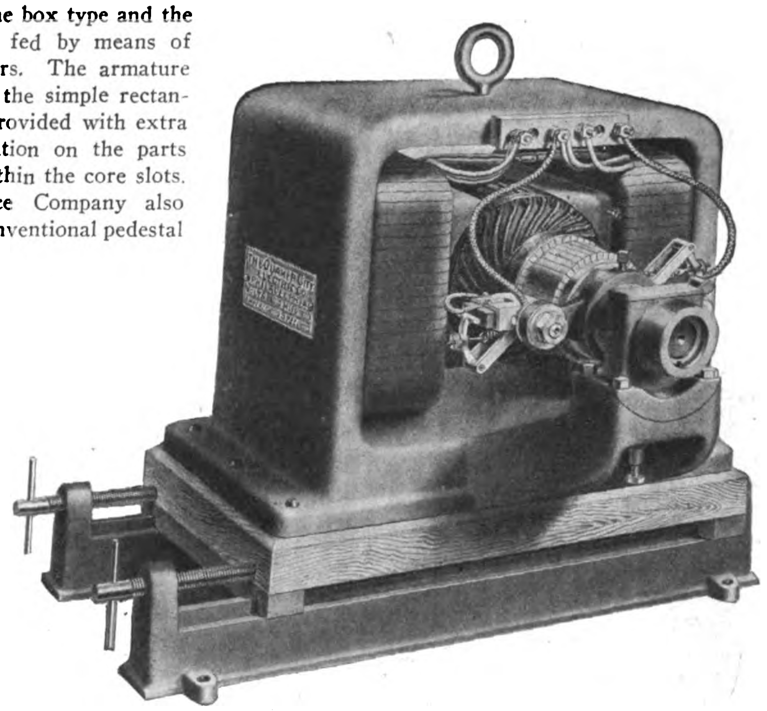


FIG. 76.—QUAKER CITY MOTOR.

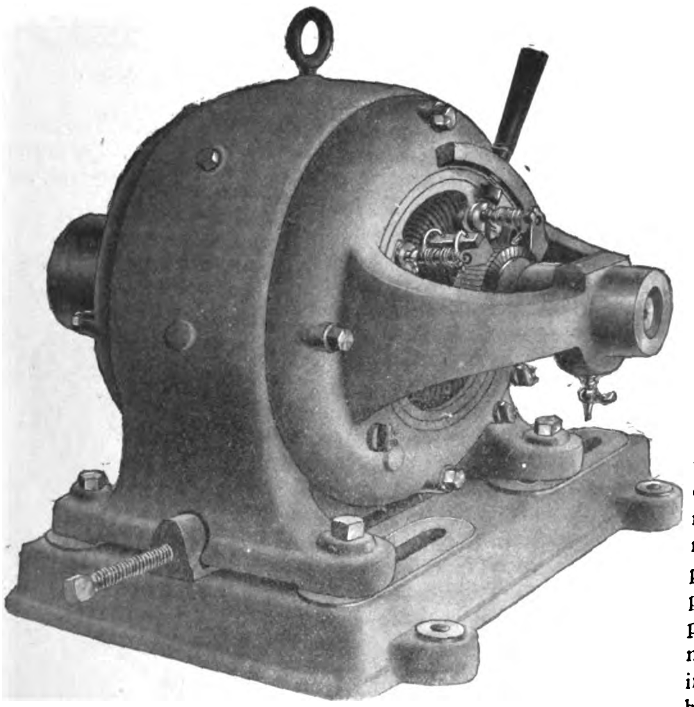


FIG. 77.—RELIANCE MOTOR.

The Reliance Electric Company builds the form of machine illustrated by Fig. 77. The yoke ring is of cast steel and the magnet poles are of the same material, but are cast separate and bolted in. They are oval in cross-section and provided with integral polar extensions. The field-magnet coils are form-wound and taped. The journal bracket casting has a recess machined in the face of the circular portion of it, and into this recess is fitted a ring which carries the brush-holder rigging. The brush-holders are of the box type and the brushes are fed by means of curved fingers. The armature coils are of the simple rectangular type provided with extra heavy insulation on the parts which lie within the core slots. The Reliance Company also builds the conventional pedestal type of machine in large sizes, the pedestals and base being cast in a single piece, and the yoke ring bolted to the base. The magnet cores are bolted to the yoke ring, as in the case of the smaller machine. The armature winding is of the straight-out type, and the brush-holders are of the pivoted type, with the brushes bolted to the ends of the pivoted arms.

Fig. 78 illustrates the multipolar motor of the Robbins & Myers Compan,y, which is built in sizes of 2 h.p. and larger. The smaller sizes are bipolar, but of the same general external appearance as the multipolar machine. In the bipolar machine the yoke rings and magnet poles are cast in one piece. In the multipolar machines the magnet poles are laminated, held together by cast iron cheek pieces and bolted to the yoke ring. Fig. 79 shows a group of magnet poles, a single stamping and two-field coils. It will be noticed that the stamping is slotted up the center from a point near the pole-face, the result of this being to reduce field distortion. The yoke ring is provided with lugs near the bottom, which are bored to fit two round slide-rails, as shown in Fig. 78, the slide-rails being mounted in lugs on a pan-shaped base. The adjusting screw is provided with a handle pivoted to its head and having a bifurcated end similar to that of an open-end wrench. The combination is practically that of a square-head screw and a substantial open-end wrench, the two being pinned together so that the wrench cannot be mislaid and does not need to be removed and reapplied to the bolt head after every half turn. The journal bracket casting, as the engraving clearly shows, is of such shape as to completely enclose the motor, with the exception of the commutator and brushes. The bearings are lined with babbitted sleeves, which are interchangeable, and the oil well is open across its entire width at the top, so that free access to the well is afforded by removing the cover plate; the latter is chained to the bearing housing to avoid its being misplaced. The armature construction is illustrated by Fig. 80. The discs are stamped with large ventilating openings near the shaft hole, and are clamped together between end-plates of peculiar construction. One of the end-plates is of such shape that

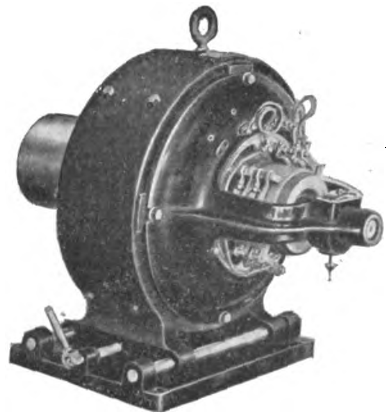


FIG. 78.—ROBBINS & MYERS MOTOR.

it acts as a fan to force a draft of air through the armature core, while the other serves as a funnel or horizontal chimney to add to the draft. The discs are keyed directly on the shaft, of course, and the end-plates project a sufficient distance to afford support for the armature coils which are of the straight-out type. The end-plate which serves as a blower is located at the front end of the armature, so that it draws air through the core and throws it out through the interlaced coils between the core and the commutator. The brush-holders are of the pivoted type, the brushes being bolted to plates of ample surface on the ends of arms pivoted on the brush-holder stud.

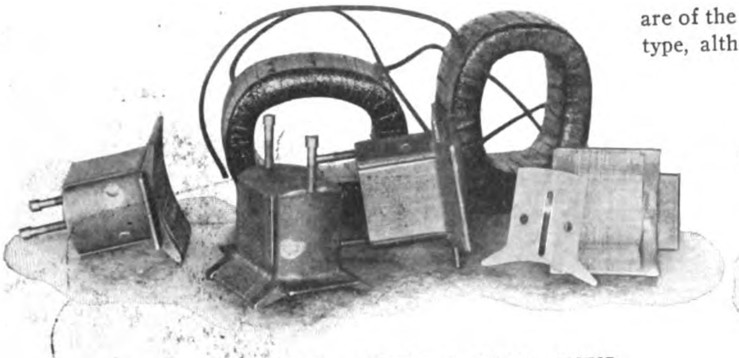


FIG. 79.—FIELD PARTS, ROBBINS & MYERS MOTOR.

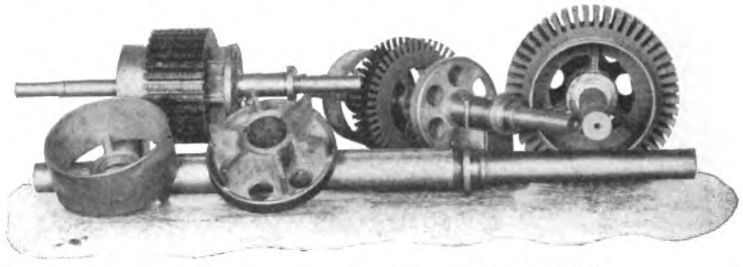


FIG. 80.—ARMATURE PARTS, ROBBINS & MYERS MOTOR.

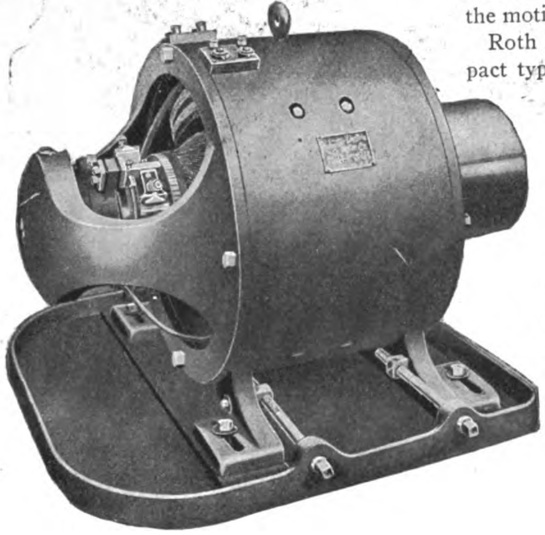


FIG. 81.—ROCHESTER MOTOR.

Fig. 81 shows the motor of the Rochester Electric Motor Company, which is of the bipolar type in sizes up to and including 3 horse-power, and is multipolar in larger sizes. The magnet poles are built up of sheet steel and bolted to the yoke ring. The shape and method of attaching the journal brackets are shown clearly by the engraving. The bearing sleeve is of phosphor-bronze, and the bearings are self-aligning. The field coils are form-wound and taped as usual, and are provided with a layer of cord around the outer surface for mechanical protection. The armature coils of the bipolar machine are wound directly into the slots; those of the multipolar machines are form-wound and are of the simple rectangular type, although they are not strictly rectangular in outline, one side of the coil being shorter than the other to facilitate intermeshing. The brush-holders are of the reaction type, but the motion of the feeding mechanism is always parallel with the motion of the brush.

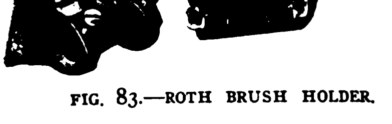


FIG. 83.—ROTH BRUSH HOLDER.

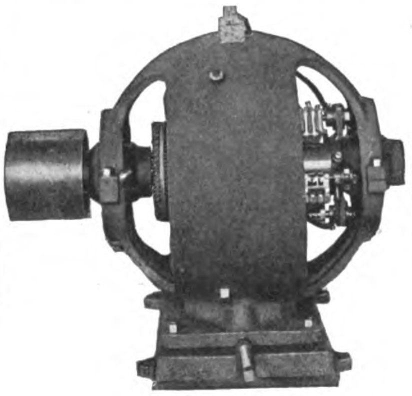


FIG. 82.—ROTH MOTOR.

Roth Brothers & Company build the compact type of machine illustrated by Fig. 82. The yoke ring is of cast iron, and the journal brackets are cast integrally with the ring. Each bracket is bored and split at the center to take the journal box casting, which is turned to fit the bore of the bracket, of course, and is clamped in position by means of bolts passed through lugs on each side of the split. The field-magnet poles are made of cast steel or wrought iron, according to the size of the machine, set into recesses in the yoke ring and bolted in place. Removable pole-shoes are provided which hold the field coils in position; the latter are wound on insulated spools. The armature coils are of the straight-out type when first wound, but the portions projecting beyond each end of the armature core are drawn down toward the shaft. The brush-holder is a modification of the box type and is illustrated by Fig. 83. The brushes are pressed against the solid part of the holder by means of flat springs, which are independent of the springs which feed the brushes toward the commutator.

The Lundell bipolar machine, built by the Sprague Electric Company, and illustrated by Fig. 84, is so well known as to require very little description. The field-magnet frame is of cast steel in two pieces, each half carrying one pole of the magnet. The poles extend axially from the point where they leave the spherical casing, and a single field coil is used, which is disposed concentric to the armature, but tilted slightly out of a true vertical plane. Fig. 85 illustrates the multipolar machine which also has the single field-coil feature. Like the bipolar machine, the field-magnet yoke is divided vertically in the center, but a tripod journal bracket is used at each end, instead of the housing which is cast integrally with the field-magnet of the bipolar machine. Curved shields are provided, which fit over the spaces between the arms of the journal bracket in the larger machine, as indicated in the lower part of Fig. 85. This machine may thus be operated as an open type, partly enclosed or completely enclosed. The brush-holders are of the parallel motion type, but no pivots are used in their construction. The brushes are bolted to plates, and these are attached to the stationary part of the holder by means of two laminated copper

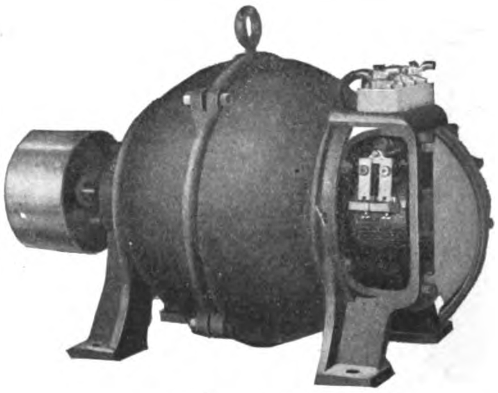


FIG. 84.—LUNDELL MOTOR.

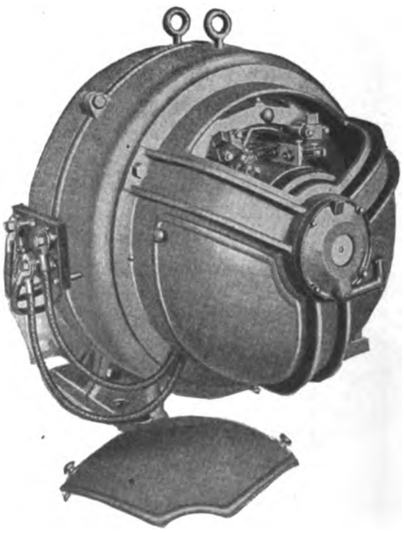


FIG. 85.—LUNDELL MOTOR.

same angle with the commutator. A flat spring is provided which presses the brush plate toward the commutator, the springy character of the copper leaf not being relied upon for this purpose. This construction is shown by Fig. 86.

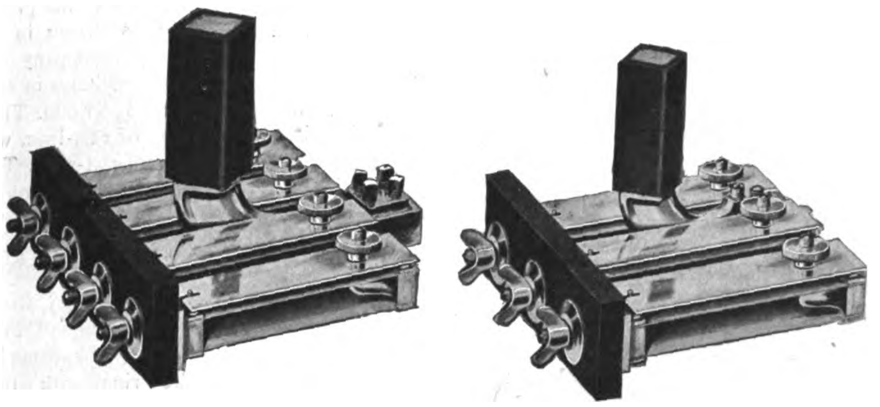
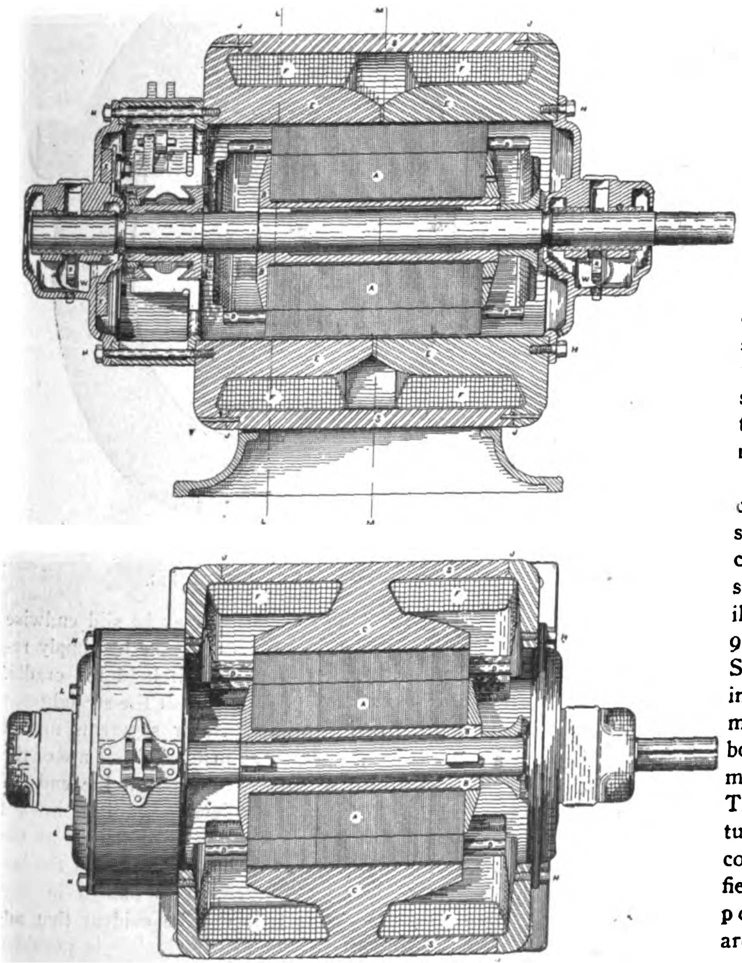


FIG. 86.—SPRAGUE BRUSH-HOLDERS



FIGS. 87 AND 88.—STOREY MOTOR SECTIONS.

The motor built by the Storey Motor & Electric Company is also of the concentric field-coil type, but is provided with two coils, and the magnet poles project alternately from the edges of the yoke ring toward the center and from the center of the yoke ring toward the ends of the armature. This construction is shown by Figs. 87 and 88, the first view being a vertical cross-section showing the two opposite poles which project inwardly from the ends of the machine, and the second being a horizontal cross-section showing the other two poles, which are cast integrally with the yoke ring. The two field-magnet coils are absolutely concentric to the armature and located one on each side of the central poles, as indicated in Fig. 88. The motor is completely enclosed, the commutator housing closing up one end of the machine, and the rear journal bracket closing the other end. The frame is of cast steel. The armature discs are mounted on a sleeve keyed to the shaft. The armature coils are form-wound and individually insulated in the usual manner; the type of armature coil has not been ascertained. The brush-holder is of the box type, with the broader sides of the box slotted to admit the tension spring. Fig. 89 shows end and plan views of the holder, and Fig. 90 illustrates the spring. The stud about which the spring is coiled is held in the boss shown at the left-hand side of Fig. 88, the set-screw, shown in the upper view, holding the stud in any position to which it may be adjusted.

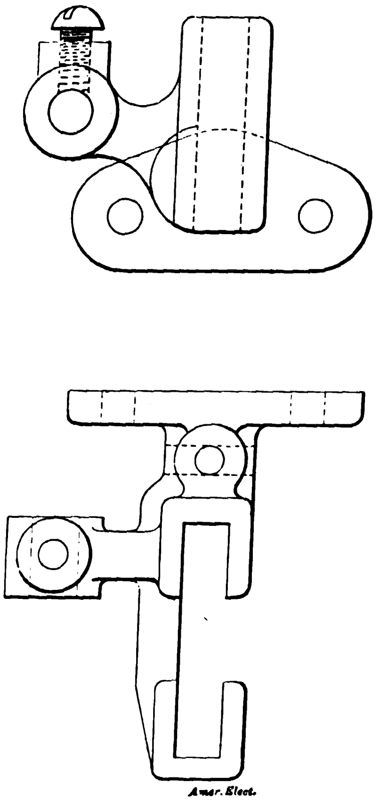


FIG. 89.—STOREY BRUSH-HOLDER.

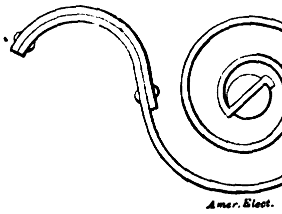


FIG. 90.—SPRING.

Among the machines which constitute individual classes by themselves is the one illustrated by Fig. 91, and built by the Stow Manufacturing Company. This machine is built in both bipolar and multipolar forms. The peculiar feature of it lies in the construction of the field-magnet, the poles of which are rectangular in outline and provided each with a wrought-iron core or plunger fitted into a pocket bored from the outside of the yoke ring to a point near the pole-face. The wrought-iron cores are provided with threaded shanks which project beyond the bosses on the exterior of the yoke ring, and the core plungers are drawn in and out by means of nuts on these threaded shanks, the nuts being turned through the medium of the bevel-gears, rods and hand-wheel shown in the engraving. When the plungers are as far in the pockets as they can go the field strength is, of course, maximum, and the motor runs at its lowest speed. Drawing the plungers outwardly

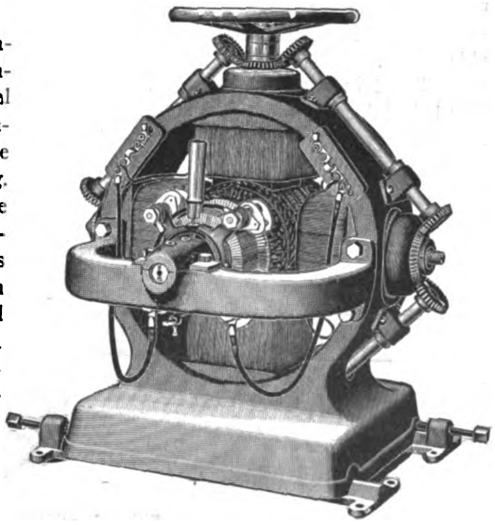


FIG. 91.—STOW MOTOR.

away from the pole-faces increases the reluctance of the magnetic circuit and therefore reduces the field flux and allows the motor to increase in speed. As that part of the pole next to the armature remains unchanged there is always a liberal commutating flux at the pole-tips, so that the commutation is not affected by weakening the field, all of the weakening taking place in the center of the pole-face. The yoke ring and the shells of the magnet poles are of cast-iron in a single piece, and there are no polar extensions; consequently, the magnet coils may be slipped on and off without disturbing any part of the field-magnet structure. The arrangement of the journal bracket is shown so plainly by the engraving as to require no explanation.

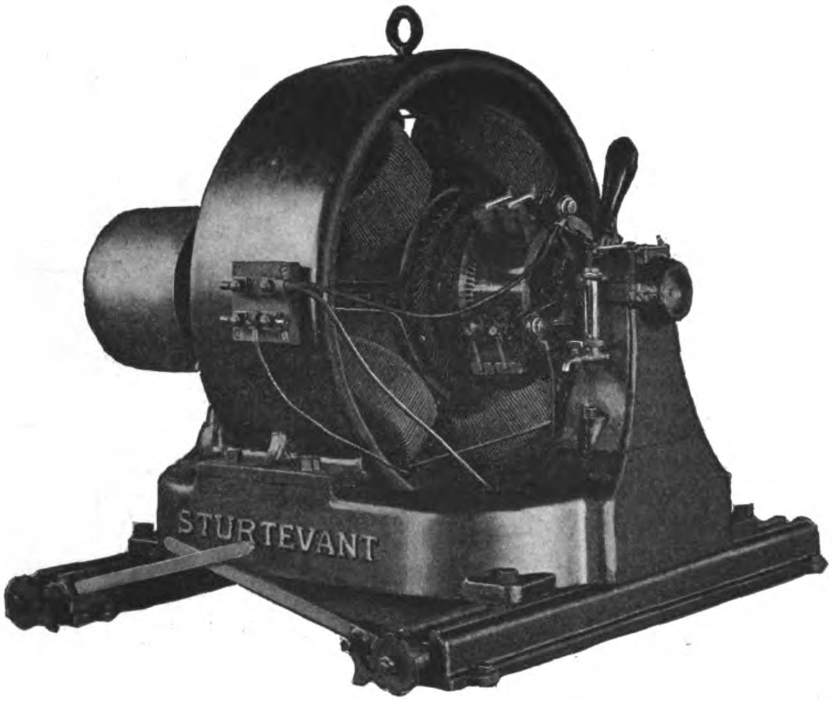


FIG. 92.—STURTEVANT MOTOR.

Fig. 92 shows the four-pole machine built by the B. F. Sturtevant Company in sizes ranging from 2½ horse-power up. The yoke ring and magnet poles are cast integrally of steel, the poles being provided with removable shoes. The magnet coils are form-wound and insulated as follows: They are first baked for two hours at a temperature of 150 degrees Fahr. and then wrapped with two layers of cotton tape; they are next saturated with an insulating compound, and then baked five hours at the same temperature as before. After this, two lays of oiled rope paper are put on, and two additional layers of finishing tape over these. The outside of the coil is finished with a heavy coat of oil, water and acid-proof varnish. The armature is form-wound, with coils of the straight-out type; on all low-voltage armatures a bar winding is used. The commutator segments are drop-forged.

The Sturtevant Company also builds a line of bipolar machines with circular yoke rings and either partly or entirely enclosed by means of circular end caps. In these machines the yoke ring is of cast-iron and the magnet poles are of steel, bolted into the ring and provided with polar extensions. The magnet coils are wound and insulated exactly in the same way as those on the larger machines just described. The armature coils are machine-wound and of such shape that when put on the core they do not require tying down at their rear end. Fig. 93 illustrates the arrangement of the coils on the core. The commutator segments of this line of machines are of drawn copper. The brush-holders are of the box type shown in Fig. 94, which illustrates the brush rigging for the bipolar machine. The ring on which the brush-holders are mounted fits in a seat on the inner surface of the enclosing end cap and is held in the proper position by the thumb nuts shown in the engraving. The Sturtevant Company also builds a line of eight-pole machines in sizes of 1 to 50 horse-power per 100 r.p.m. These machines have yoke rings of cast-iron, with removable magnet cores of cast-steel. They are built in two styles, one having journal brackets of the tripod type and the other having the ordinary form of journal pedestal.

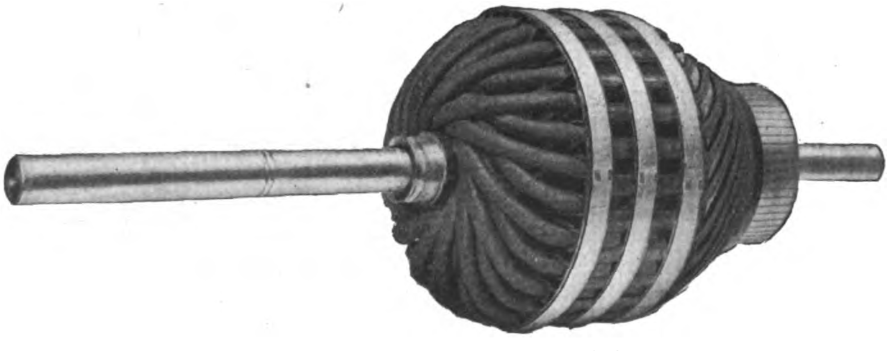


FIG. 93.—STURTEVANT ARMATURE.

Fig. 95 illustrates the medium size of motor built by the New England Motor Company. This is a four-pole machine having a cast-iron yoke ring, with round wrought-iron magnet cores bolted to the ring, and laminated pole-shoes secured to the ends of the magnet cores. A noteworthy feature of the machine is the arrangement of the bearings; the lower halves of the journal boxes are cast in one piece with a cradle structure, as shown in Fig. 96, so that the bearings and armature may be slid endwise out of the field-magnet frame by simply removing three bolts which hold the cradle. The armature winding is of the straight-out type and the commutator segments are of drawn copper. The brush-holders are of the box type and are mounted on the ends of L-shaped lugs, projecting radialy inward from a ring of the same diameter as the yoke ring and bolted to the edge of the latter. This arrangement is shown in Fig. 95, from which it will be evident that adjustment of the brush rigging is provided for by slots in the ring.

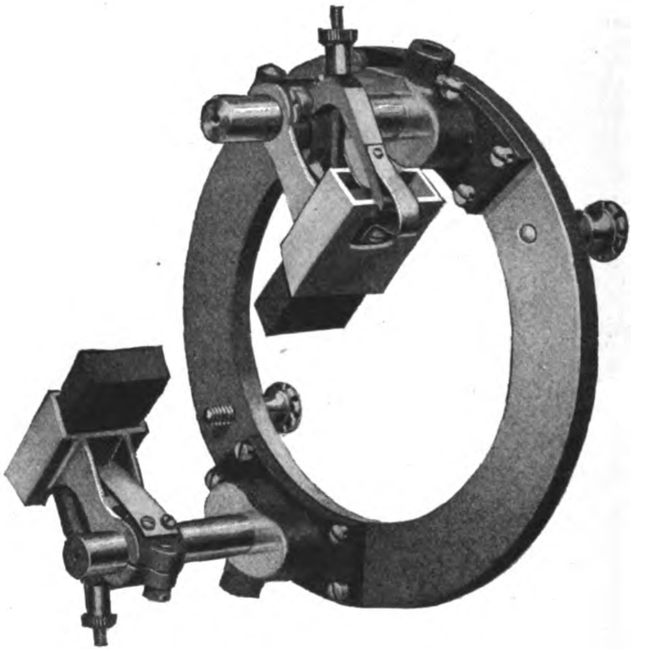


FIG. 94.—STURTEVANT BRUSH RIG.

In large sizes, the New England machine is of the type illustrated in Fig. 97, except that the cross-section of the yoke ring as now built is more nearly a semi-oval, the outer surface being heavily curved and the inner surface being parallel with the shaft. The magnet cores are of round wrought-iron cast-welded into the yoke ring, which is of cast-iron, and provided with removable pole-shoes. The armature discs are unusually thin, there being about 50 laminations per inch of armature length. The discs are mounted on a spider which also carries the commutator shell, and paper is used as an insulating medium between the discs. As in the small machines, the armature coils are of the straight-out type; they are held in the slots by wooden wedges. The New England Motor Company also builds a smaller line of bipolar machines, which are very similar in outward appearance to the four-pole machine illustrated by Fig. 95, and also embody the same general features of construction.

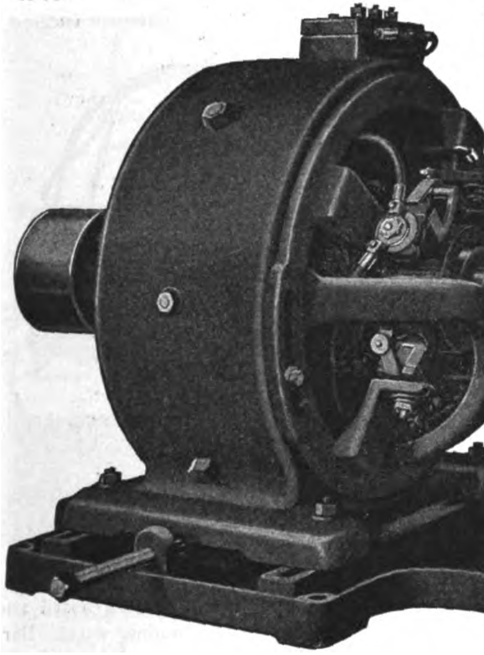


FIG. 95.—SEMI-ENCLOSED NEW ENGLAND MOTOR.

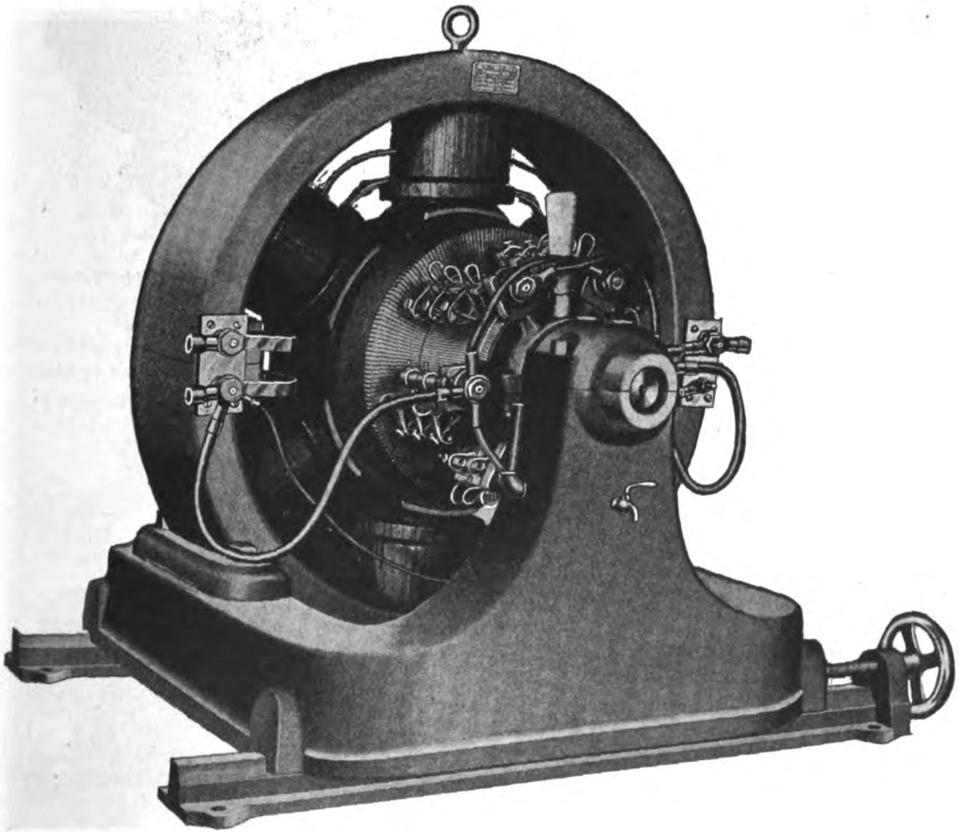


FIG. 97.—NEW ENGLAND MOTOR.

The semi-enclosed motor of the Triumph Electric Company is shown by Fig. 98. This is a four-pole machine with a cast-iron yoke ring, having laminated magnet poles cast-welded into the frame and equipped with pole-shoes which embrace the ends of the cores. The magnet pole construction is more clearly indicated in Fig. 99, which shows the open type of Triumph machine as built in large sizes. The form shown in Fig. 99 is also built in small sizes, but in those sizes the yoke ring is not divided horizontally and the journal pedestals are not cast integrally with the base, but are mounted on curved seats bored to the same radius as that of the polar faces. This construction, it will be obvious, is necessary in order to permit the armature to be inserted and removed, when the yoke ring is in a single piece and integral with the base. The construction of the journal bracket of the semi-enclosed machine is made obvious by Fig. 98. These machines may be entirely enclosed by the application of curved shields which are made to fit closely over the openings on each side of the commutator.

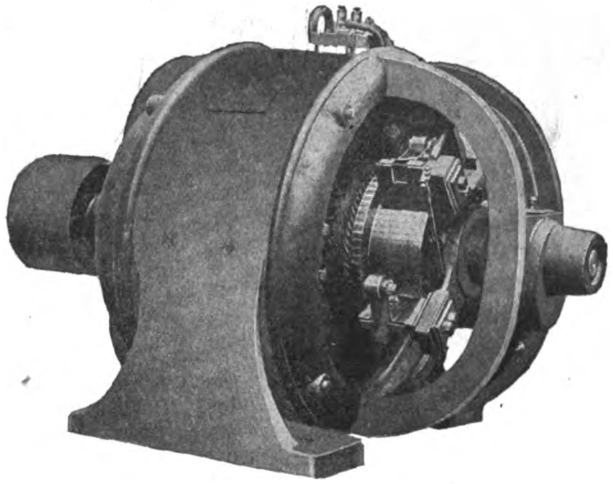


FIG. 98.—TRIUMPH MOTOR.

The field-magnet coils of all Triumph machines are form-wound and a layer of insulating material is inserted between each layer of wire. After the coil is wound it is dipped in a bath of insulating varnish, then thoroughly baked and covered with fuller board, mica and canvas, with a layer of tape over the whole. It is then given a layer of cord for mechanical protection, and finished with a coat of insulating and weather-proof varnish. The armatures of the machines in all sizes are bar-wound for low voltages and wire-wound for higher ones, the coils in all cases being of the Eickemeyer type and individually insulated throughout their length. In small sizes, the armature discs are mounted directly on the shaft, and in larger ones, an intervening spider is used. In both cases ventilating ducts, both parallel with the shaft and in a transverse direction, are provided. In all of the bar-wound armatures the coils are held in the slots by wooden wedges; this is also true of most of the wire-wound armatures, band wires being used only in the small sizes of wire-wound machines. The commutator segments are either hard-drawn or drop-forged to gauge, according to the sizes of the machine.

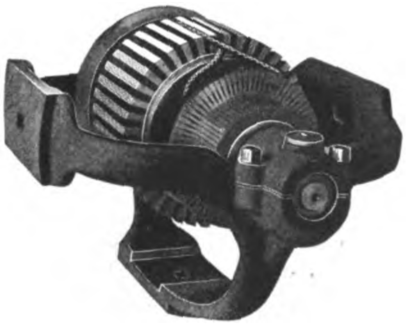


FIG. 96.—NEW ENGLAND YOKE AND ARMATURE.

The brush-holders of the small sizes are of the box-type; one of them is illustrated by Fig. 100, from which the construction will be evident. The brush-holders of the larger machines are of the pivoted type, each brush being clamped solidly in a box at the extremity of an arm which is pivoted to the stationary part of the holder. Supplementary connections are used between the stationary and removable parts of the holder to relieve the pivots from serving as part of the electrical circuit. The tension is adjustable by means of thumb screws, as indicated in the engraving.

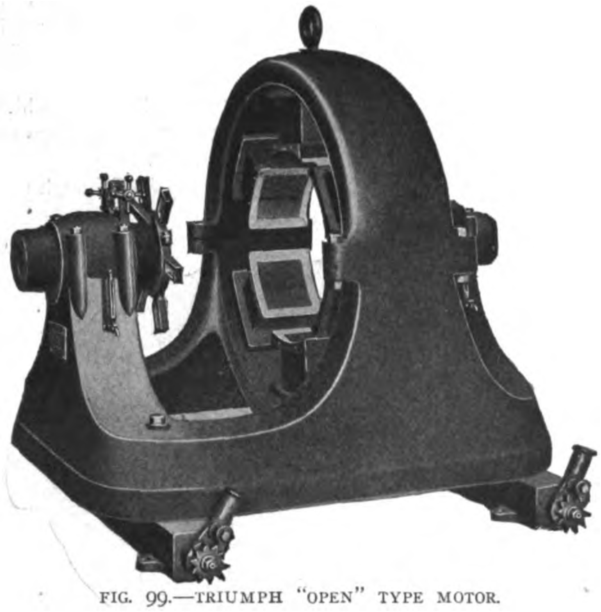


FIG. 99.—TRIUMPH "OPEN" TYPE MOTOR.

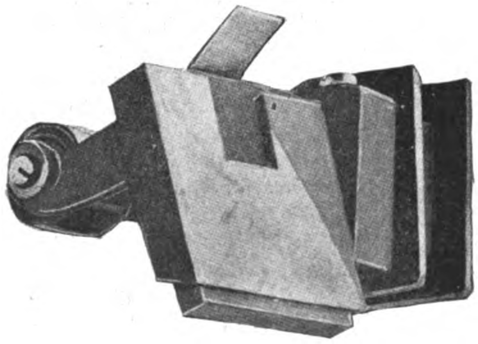


FIG. 100.—TRIUMPH BOX BRUSH-HOLDER.

The Triumph Company also builds a slow-speed enclosed motor for direct-connected service, which embodies the same general features of magnet and armature construction as those just described. The machine is provided, however, with a journal bracket of the tripod type, and the yoke ring is closed in on each side by means of a perforated disc. At the commutator end, the enclosing disc or cap encircles the commutator at the connecting lugs, leaving the commutator barrel and the brushes exposed, so that the operation of the machine may be noted and any necessary adjustment made without removing the enclosing cap.

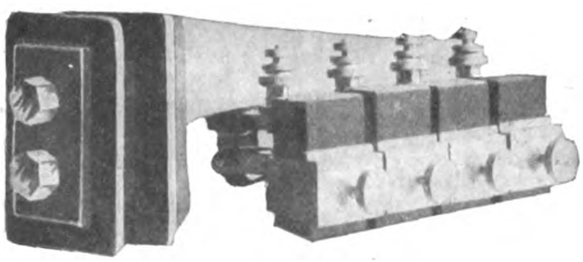


FIG. 101.—TRIUMPH PIVOTED BRUSH-HOLDERS.

The semi-enclosed motor built by the Western Electric Company is illustrated by Fig. 102. The yoke ring and magnet cores are of cast-steel, the cores being circular in cross-section and bolted into the ring; polar extensions are cast on the ends of the cores. These machines are made completely enclosed by the application of curved shield plates which have mica windows in them in order to allow inspection of the commutator and brushes without the removal of the shield plates. The open type of Western Electric machine is shown by Fig. 103. As in the other case, the yoke ring is of cast-steel, with round cast-steel magnet cores bolted into it, the cores being provided with polar extensions. This construction is employed in all of the small and medium size machines; in large machines the magnet poles are laminated, the sheets being stamped with polar extensions and the built-up cores being bolted in the yoke.

The armature coils of all of the multipolar machines are of the rectangular type, and the commutator segments are of hard-drawn copper. The brush-holders are of the parallel-motion type somewhat similar to that shown by Fig. 31. The movable part of the holder is a box, attached to the stationary part by means of parallel laminated conducting strips, and is pressed toward the commutator by means of a flat phosphor-bronze spring. The brush is held in the box by means of a heavy thumb-screw and a clamping plate.

Fig. 104 illustrates the standard-direct-current machine of the Westinghouse Electric & Manufacturing Company. The yoke ring of this machine is of cast-iron, and laminated pole pieces are cast-welded into the ring. Pole-shoes are not employed; one pole tip of each plate is cut off at an angle of about 45 degrees with a radial line drawn down the center of the plate, and the plates are turned first one way and then the other, the result being that at the pole tips or edges there is only one-half the metal that would otherwise be there. This construction is employed in order to saturate the pole-tips and reduce field distortion. As shown in the engraving, the journal pedestals of the smaller machines are mounted on circular seats; in larger sizes the yoke ring is divided horizontally and the journal pedestals are then cast in one piece with the base and lower half of the yoke ring. The field-magnet coils are not only wound in forms, but are machine-wound, in order to obtain absolute regularity. They are heavily insulated and baked.

Two forms of armature coil are used, the Eickemeyer type and a modification of the rectangular type; these are shown in Fig. 105. Fig. 106 shows an armature core partly wound with the modified rectangular type. In machines of such size or voltage as to require wire armature coils these are encased in envelopes of prepared fuller-board and are held in the slots by binding wires. Bar-wound armatures in smaller sizes also have binding wires to hold the coils in place, but in larger machines they are retained by fiber wedges forced into notches near the tops of the teeth. In low-potential machines, pivot or swivel brush-holders are used, and in the high-potential machines the box type of brush-holder is used; the reason for this differentiation is obviously that the pivoted type of holder insures less drop in the brush

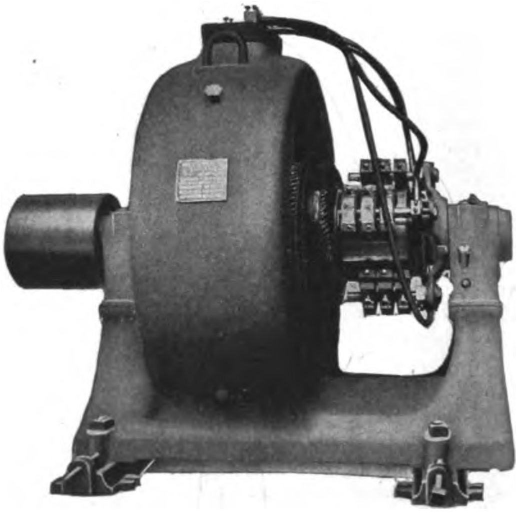


FIG. 103.—WESTERN ELECTRIC MOTOR.

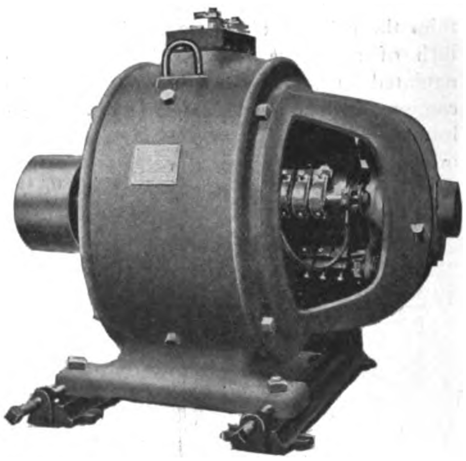


FIG. 102.—WESTERN ELECTRIC SEMI-ENCLOSED MOTOR.

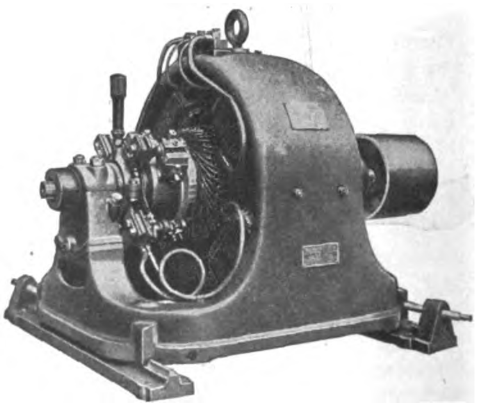
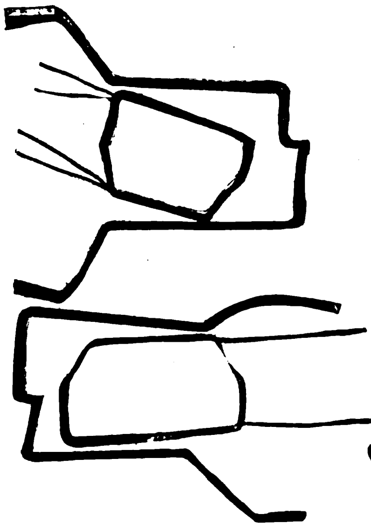


FIG. 104.—WESTINGHOUSE MOTOR.

rigging than the box type, and in low-voltage machines the drop at this point must necessarily be made as small as possible. Fig. 107 shows the box type of holder and Fig. 108 illustrates the pivoted type. Figs. 109 and 110 illustrate respectively the complete brush rigging for the two different styles of holder manufactured by this company.



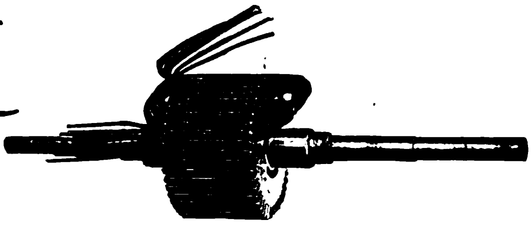


FIG. 105.—WESTINGHOUSE ARMATURE COILS AND PARTLY-WOUND ARMATURE.—FIG. 106.

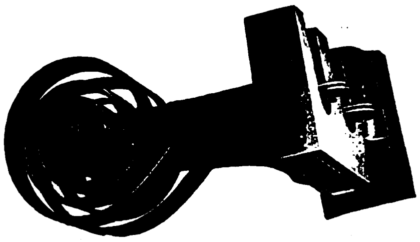


FIG. 107.—BOX-TYPE OF BRUSH-HOLDER.

In machines too large to admit of the use of the two-path or so-called series armature winding, the ordinary lap winding is employed, and equalizing rings are applied to the commutator so as to connect segments that should be of equal potential. Differences in the different strength of different field magnet poles, therefore, do not cause the trouble which would be entailed without these equalizing connections.

FIG. 108.—PIVOTED BRUSH-HOLDER.

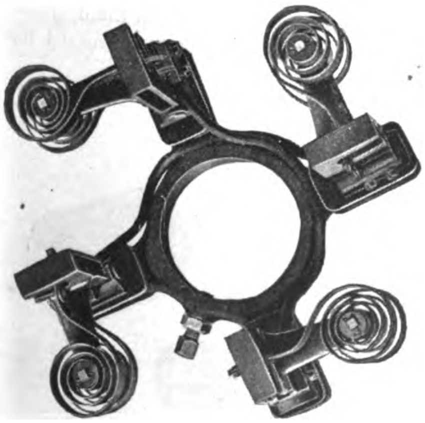


FIG. 109.—WESTINGHOUSE BRUSH RIGGING.

Fig. 111 illustrates one of the enclosed forms of motor built by the E. G. Bernard Company. The yoke ring is of cast-iron, and in the small sizes the magnet poles are of the same material. The magnet coils are form-wound and insulated in the usual manner. The armature winding is of the straight-out type and the brush-holders are of the reaction type. Fig. 112 illustrates a standard Bernard machine built in medium and large sizes. The yoke ring of this machine is also of cast-iron, but the magnet poles are laminated and cast-welded into the ring. As the engraving shows, the base and journal pedestals are cast in a single piece, the yoke ring being bolted to the base. In the machines of this type of moderate size the yoke ring is in a single piece, but in larger sizes it is divided horizontally, as illustrated in the engraving. Like the factory type of motor, shown by Fig. 111, the magnet and armature coils are form-wound and the latter are of the straight-out type; the reaction type of brush-holder is also used in this machine.

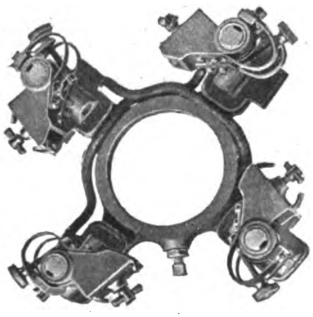


FIG. 110.—WESTINGHOUSE BRUSH RIGGING.

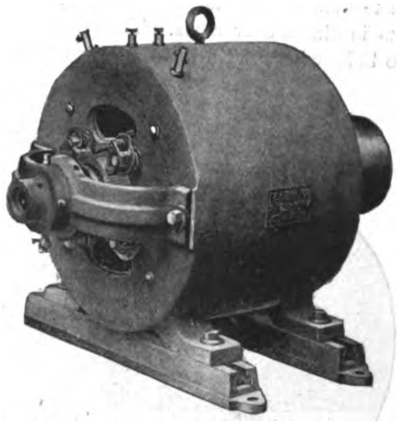


FIG. 111.—BERNARD ENCLOSED MOTOR.

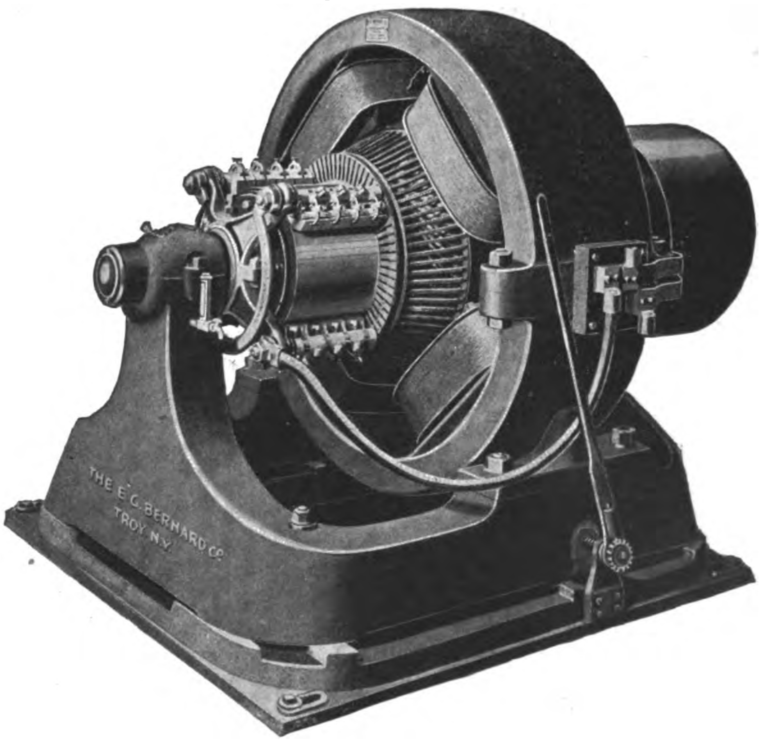


FIG. 112.—BERNARD STANDARD MOTOR.

The open type of machine built by Jantz & Leist Electric Company is illustrated by Fig. 113, from which it will be obvious that the yoke ring and base are cast together, and the journal pedestals are bolted on. In larger sizes, the yoke ring is divided horizontally, and the journal pedestals are then cast in one piece with the base. The magnet poles of all sizes are cast-welded into the yoke and provided with form-wound coils, which are insulated in the usual way and protected by an outer layer of heavy cord. This company also builds a semi-enclosed and completely enclosed type of motor of similar general construction to the machine shown by Fig. 75.

Fig. 114 illustrates the multipolar motor built by the M. & O. Company, which was organized a short time ago in Milwaukee. The yoke ring of the machine is of cast-iron, and the magnet poles are bolted to the ring. The journal bracket at the commutator end, as the engraving shows, is of the ring and double-arm type; the bracket at the pulley end has four arms instead of two. The field and armature coils are form-wound. The brush-holders are of the reaction type and the shanks are mounted in rectangular slots in the rocker arms. This machine is also built with a solid journal bracket at the pulley end and shields at the commutator end, which close the openings there.

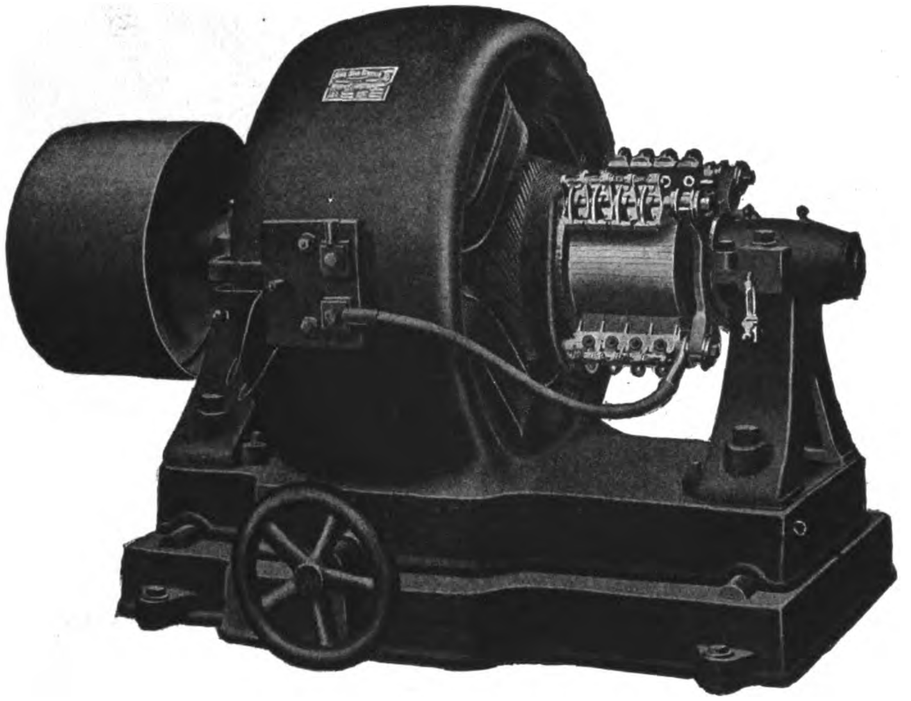


FIG. 113.—JANTZ & LEIST MOTOR.

Alternating-Current Motors.

With one exception, all of the alternating-current induction motors built in this country are of substantially the same type. The stator is built up of sheet iron or steel rings, having slots punched around its inner circumference for the reception of the stator winding, and the rotor core is similar to that of an ordinary direct-current armature, except as to the shape of the slots, which are sometimes rectangular and sometimes round, but always nearly closed at the core periphery. The rotor winding is either composed of copper bars all joined at the ends by connecting rings (the squirrel cage type) or is a polar winding divided up into three circuits, the terminals of which are led to resistance coils which are used for starting the machine up from stand-still.

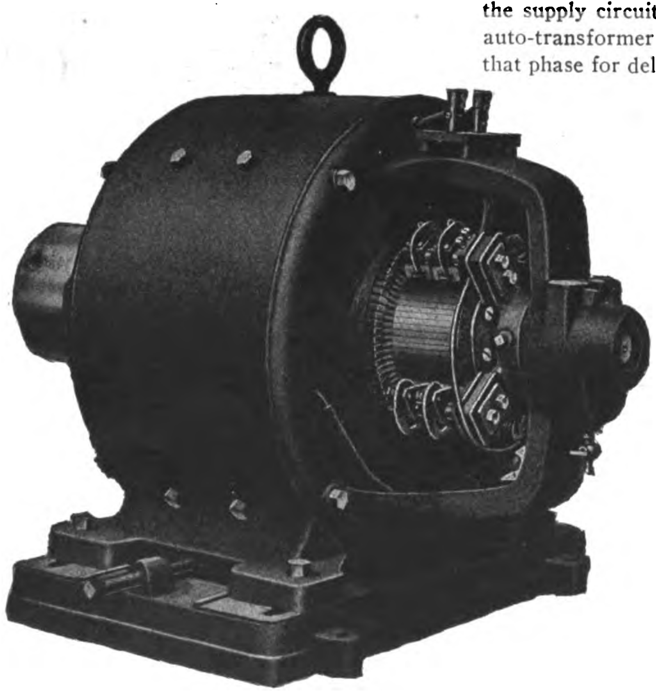


FIG. 114.—M. & O. MOTOR.

The self-starting single-phase induction motor built by the General Electric Company is illustrated by Fig. 115. This machine is provided with a polyphase winding on the stator, one circuit of which is connected to the supply circuit, and the other to a small auto-transformer which raises the e.m.f of that phase for delivery to a compensator, the function of which is to displace the phase of the winding to which it is connected with relation to that of the main supply circuit. The result is a rotating field similar to that produced in an ordinary polyphase motor. Another result of this combination is that the power-factor of the machine is greatly improved, being unity at full load and over 95 per cent at half load in small machines. The motor, of course, will start under load and the improvement of its power-factor by means of the compensator considerably reduces the starting current required to produce a given torque. These machines are built for frequencies as high as 125.

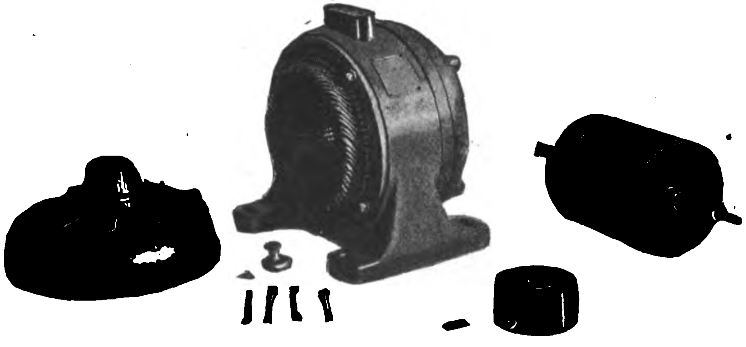


FIG. 115.—G. E. SINGLE-PHASE SELF-STARTING INDUCTION MOTOR.

Fig. 116 illustrates a polyphase machine of large size, and Fig. 117 is the rotor of this machine. This machine is of the same general construction as the small one just described, the stator being wound with two or three circuits, according to the number of phases in the supply circuit. The rotor is either of the squirrel-cage type, or provided with a starting resistance located on the interior of the rotor spider, according to the class of service to be performed. The machine shown by Figs. 116 and 117 is of the latter type. The small knob shown projecting from the end of the armature shaft enables the attendant to cut out the starting resistance when the machine has come up to speed. Large sizes of squirrel-cage machine are provided with compensators or auto-transformers which serve to reduce the voltage at the terminals of the stator windings during the period of starting, and thereby reduce the inrush of current. Fig. 118 is a diagram of the compensator or auto-transformer connections. The compensator winding is connected up Y-fashion and the terminals are led to the jaws of the starting switch, as indicated in the diagram. When the switch is thrown downward for starting the three compensator coils are inserted between the motor terminals and the line, and when it is thrown upward the terminals are connected directly to the line, the six upper jaws being connected in pairs. This

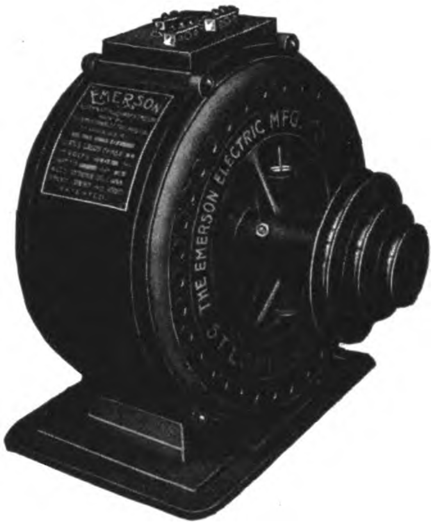


FIG. 119.—EMERSON INDUCTION MOTOR.

type of machine, of course, does not give the same starting torque as the one with the resistance inserted in the rotor circuits. For full-load torque, it requires about four times the full-load running current, whereas the machine with the starting resistance gives a maximum starting torque equal to the full-load torque of about full-load current, or a torque 50 per cent greater than the full-load running torque, with about 50 per cent more than full-load running current.

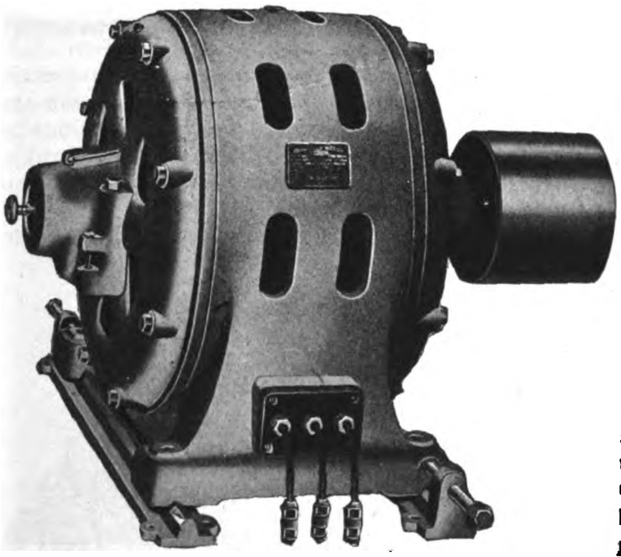


FIG. 116.—G. E. POLYPHASE MOTOR.

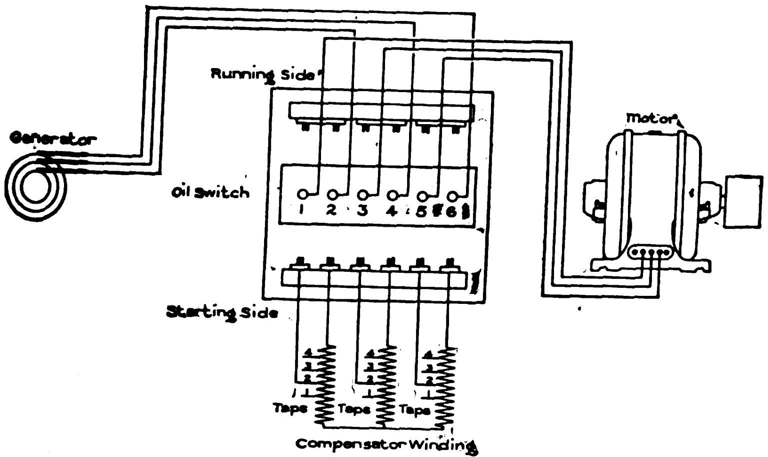


FIG. 118.—G. E. COMPENSATOR CONNECTIONS.

The Emerson Electric Manufacturing Company builds a line of small single-phase induction motors, the outward appearance of which is shown by Fig. 119. The stator carries two windings, one much heavier than the other, and the two being staggered with respect to each other, like the windings of a two-phase stator. The starting winding is made up of fine wire coils, used merely to provide a field differing in phase 90 degrees from the main field for the purpose of starting. The difference in phase between the two field fluxes is due to the difference between the inductances of the two windings. The connections are as shown by Fig. 120. When the rotor has attained normal speed, the starting winding is thrown out of circuit. The rotor is of the squirrel-cage type, the conductors being connected at the ends by heavy copper rings.

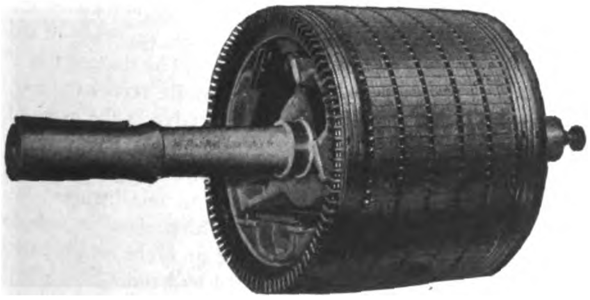


FIG. 117.—G. E. POLYPHASE ROTOR.

Fig. 121 illustrates the stator of the single-phase self-starting motor built by the Holtzer-Cabot Electric Company, from which it will be seen that the machine is provided with two windings arranged as just described in the case of the Emerson machine. As the engraving indicates, the coils of the starting winding are much smaller than those of the main winding, and as just stated in the preceding description, the difference between the inductances of the two windings causes a displacement in phase which gives a sufficiently regular rotating field to start the machine up. The starting winding is thrown out of circuit when the rotor attains normal speed. The rotor is of the squirrel-cage type, the conductors being pressed into holes in massive connecting rings at the ends of the core.

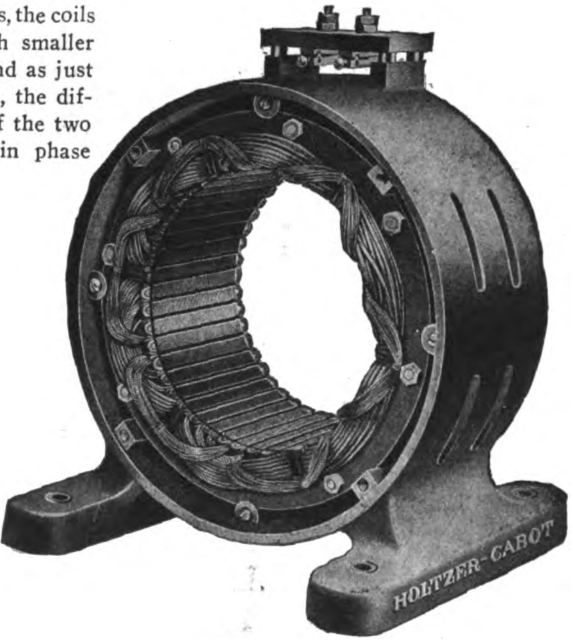


FIG. 121.—STATOR OF HOLTZER-CABOT MOTOR.

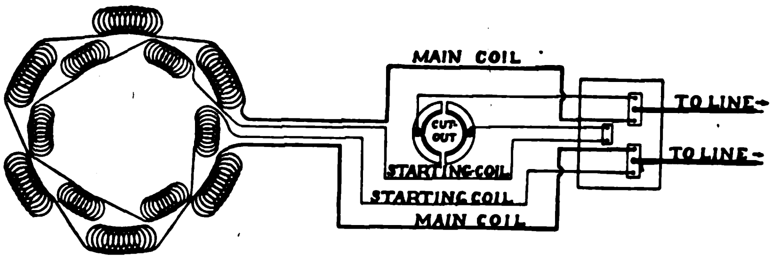


FIG. 120.—DIAGRAM OF CONNECTIONS, EMERSON MOTOR.

The Wagner Electric Manufacturing Company builds a single-phase alternating-current motor which is the exception to the general type mentioned in the introductory paragraph of this section. Fig. 122 shows an axial section of this machine, and includes most of the salient features which differentiate it from the ordinary induction motor. The armature winding is similar to that of a direct-current machine, being made up of coils connected to a commutator. The machine is started up as a commutator alternating-current motor, and as it approaches normal speed the centrifugal governor device shown in the engraving short-circuits the commutator, closing all of the coils on themselves and converting the winding into the equivalent of a squirrel-cage winding; simultaneously the brushes are lifted from the commutator and the machine proceeds to run as an ordinary single-phase induction motor. When it is desirable to secure high power-factors the machine is equipped with a condenser connected to its terminals, which raises the power-factor to a point between 96 per cent and unity, according to the size of the machine and the proportion of full load that it is carrying.

The induction motor of the Westinghouse Electric & Manufacturing Company is illustrated by Figs. 123, 124 and 125. Fig. 123 shows a stator ready to receive the winding, and Fig. 124 shows it with the winding in place. Fig. 125 illustrates the squirrel-cage form of rotor used by this company. The conductor bars are of rectangular cross-section, and each end is riveted to the periphery of a heavy connector ring. An auto-transformer is used in connection with motors of considerable size for starting the machines up. The arrangement of the coils and switch connections is substantially as shown in Fig. 118 for three-phase machines; the arrangement for two-phase machines differs, of course, only in the number of auto-transformer windings and connections. In very large sizes, the stator rings are built up of segments dovetailed and fitted into corresponding slots in the cylindrical shell of the machine.

In conclusion, the writer desires to express his appreciation of the cordial assistance rendered by the various manufacturers in supplying data and illustrative material for this article. It was the original scheme of the article to arrange the descriptions of the various machines in alphabetical order, so that the sequence of the descriptions could not be construed to indicate partisanship on the part of the writer. So far as possible, this scheme has been adhered to, but unavoidable delays in the receipt of material and engravings compelled its abandonment in the cases of a few of the machines.

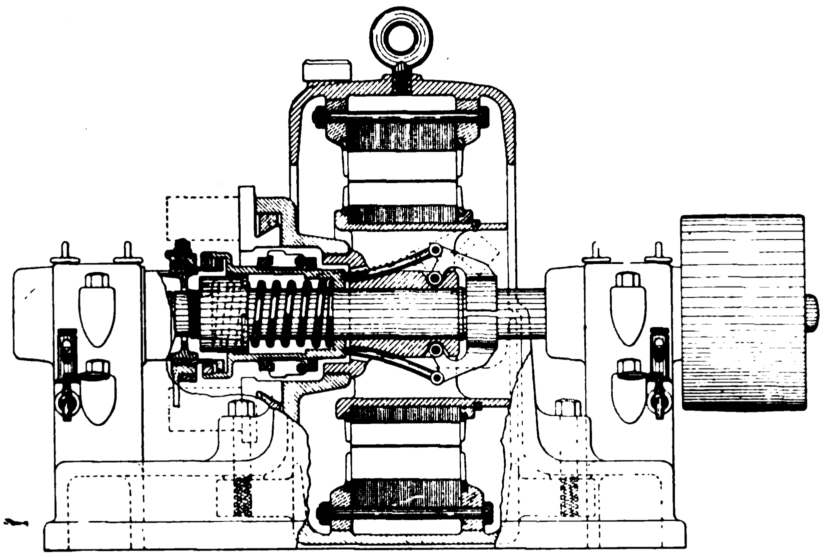


FIG. 122.—LONGITUDINAL CROSS-SECTION OF WAGNER MOTOR.

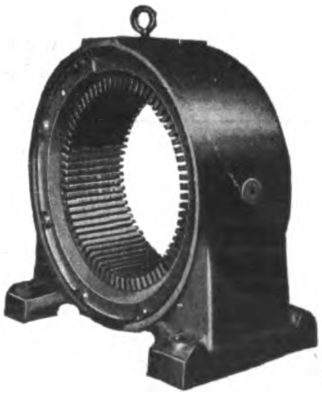


FIG. 123.

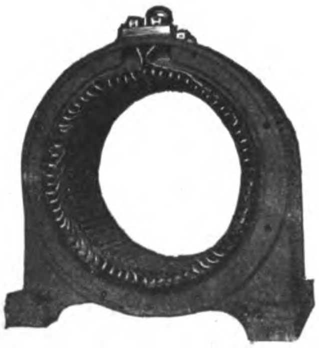


FIG. 124.

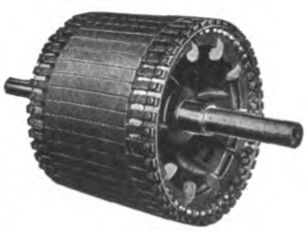


FIG. 125.

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Mr. H. H. Humphrey Honored.—At the annual meeting of the Engineers' Club of St. Louis, held on December 3, the executive committee awarded to Mr. H. H. Humphrey the annual prize of $50 in gold and an engraved certificate for the best paper presented to the club during the expired year. The subject of this paper was "The Use of Beaumont Oil as Fuel."

Abstracts from Foreign Contemporaries

Feed-Water Filter.—The feed-water filter shown in section by Fig. 1 is described in a recent issue of the London *Mechanical Engineer*. The water enters the filter at the branch *B* and passes through openings in the division plate *D* to the space *E*, thence through openings in the movable plate *F* to the first filtering division *H*. This division is filled with coir fiber made up in a spongy form, so that when pressed by the plate *F*, which is moved up or down by the screw *J*, it expands back to its original form when the pressure is relaxed. This is accomplished by inserting a spiral spring in the fiber. From the division *H* the feed water passes through perforations in the plate *K*, which is held in a position to resist pressure by the cover *A*. Division *M* is also filled with filtering material, and as the division plate *N* is without openings and fitted nearly watertight, the feed-water has to take a side course and pass through openings in the upper portion of longitudinal division plate *D* and turn again through perforations in plate *D* into the top division *O*, from where it passes to the outlet branch *C*. The arrows show the course of the feed water from the inlet through the filtering medium to the outlet *C*. At the point where the water leaves division *M* and turns into division *O*, oil or air, if present, will by reason of the breaking up of the water, and the side, and somewhat downward course it takes in entering division *O* ascend into the dome *P*, from where it can be ejected by the valve *R*. The by-pass *S* only comes into action when too much pressure is required to force the feed-water through the filtering medium. When this does occur the relief valve *T*, which is held on to its seat by the spring *U*, is lifted, and the feed-water passes by the division *O* and the outlet branch *C* to the boiler without filtration, excepting oil, air, or any other particles lighter than the water, which by reason of the strong upward course to the dome *P* goes there, and from where it may be blown off by the valve *R*. The valve spindle *V* passes through the sleeve *W*, which in turn passes through and is screwed into the top of the dome at *X*, thereby forming an abutment for the upper end of the spring *U* and by which the pressure on the spring can be regulated. The flanged nut *Y* on the end of valve spindle serves the purpose of holding up the valve in the event of the regulating sleeve *W* being screwed up sufficiently to lift the valve *T* quite clear of its seat, and admit of an unobstructed by-pass to the boiler. It also gives an outside medium by which the pressure on the relief valve *T* may be tested by hand.

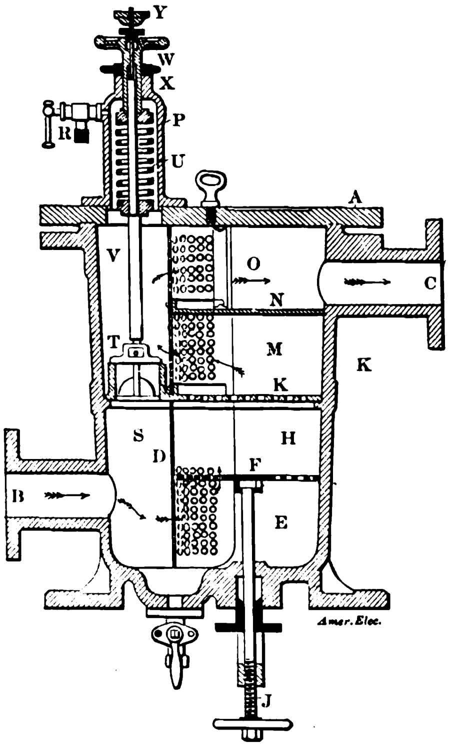


FIG. 1.—FEED-WATER FILTER.

Variable-Speed Three-Phase Motors.—Dr. H. Behn Eschenburg contributes to a recent number of the London *Electrician* an interesting description of three-phase motors built by the Oerlikon Company. This company has for a number of years built

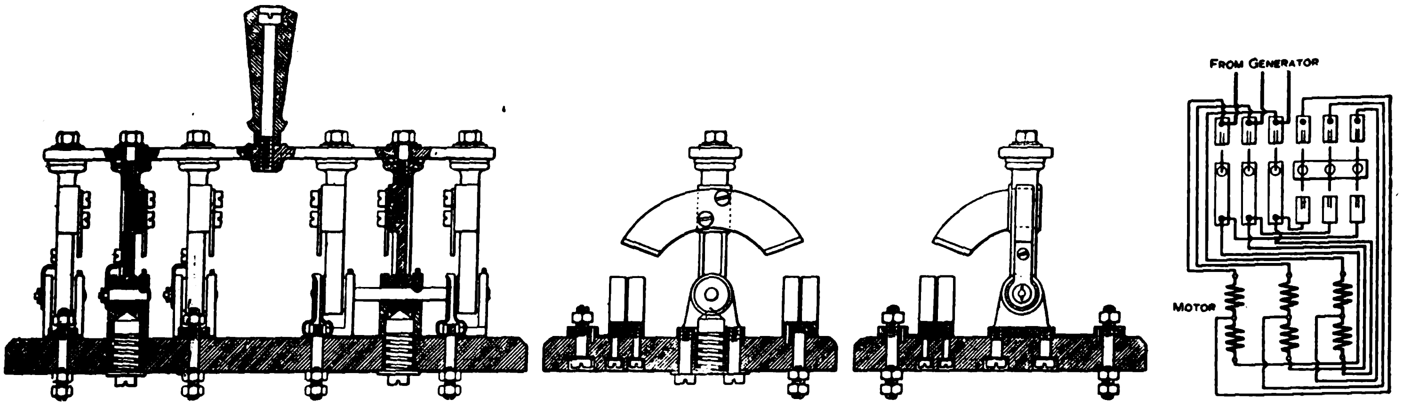


FIG. 2.—POLE CHANGE-OVER SWITCH FOR TWO SPEEDS, WITH CONNECTIONS.

three-phase motors in which the number of poles could be changed by means of a change-over switch whose terminals were connected to different subdivisions of the inducing winding. The motors of that time were arranged with a Gramme ring inducing winding connected as shown by Fig. 3. In accordance with this arrangement the winding of the motor must be divided into six groups of coils if the change-over is from 2 to 4 poles, and into 6 x 2 groups if the change-over is from 4 to 8 poles, since in this latter case the winding arrangement may be considered as two 2-to-4-pole arrangements coupled in series. The six groups of coils are divided into three phases by means of three permanent connections between each pair to which the two coils belonging to one phase are connected. There are three connections from each of these phases to the switch, making nine connections in all. In order to produce a 4-pole field, the two groups of coils belonging to one phase are connected in series by means of the change-over switch, whilst for the 2-pole field, they are connected in parallel. In recent years, drum windings have been almost invariably employed for three-phase motors, because of their advantages from a constructional view-point, and their good electrical and magnetic properties. The method of changing the number of poles in drum windings, as first employed by the Oerlikon Company, consisted in placing two independent inducing windings, and in some cases also providing two induced windings, in the same slots, one winding being arranged for the one number of poles and the other winding for the other number of poles. This arrangement had the obvious advantage of leaving the choice of the two numbers of poles quite open, making the sizes of the two windings quite independent—a point of some importance in those cases in which the load on the motor with one number of poles is quite different from that with the other. The disadvantage of the arrangement, however, is the fact that special slots have to be employed in order to obtain the extra space required for the second winding. After some investigation of the windings of three-phase motors, the Oerlikon Company finally adopted a type of drum winding which avoided the above disadvantages and enabled equally good results to be obtained as with the ordinary motor wound for one number of poles only. This winding has symmetrically arranged coils, as in the case of a direct-current armature, and is divided into *6 p* groups of coils exactly as for the old ring winding, *p* being the smallest number of pairs of poles employed. These groups of coils are changed over from *p* pairs to *2 p* pairs of poles by a change-over switch, every two groups of coils belonging to one phase being coupled in parallel for *p* pairs of poles and in series for *2 p* pairs of poles. This arrangeemnt of connections applies to motors with constant torque, and there must be at least six motor terminals. By simply interchanging the winding ends which are connected to the neutral point with those which are connected to the supply mains it is easy to see that three of the terminals shown in Fig. 2 become superfluous. Thus, in Fig. 3 connections 7, 8 and 9 are permanently short-circuited together, and for the two-pole arrangement the three-phase currents are supplied through terminals 4, 5 and 6, terminals 1, 2 and 3 being also short-circuited together. On the other hand, for the 4-pole connection the supply is connected to terminals 1, 2 and 3, terminals 7, 8 and 9 still remaining connected to a common point. A still simpler connection has been introduced on motors whose torque may be lower at the high speed than at the low speed. Instead of star-connecting the six-coil groups, they are mesh-connected, by which means the whole six coils remain permanently connected in series both for the 2-pole and 4-pole arrangements, and in fact, for any multiple of these two numbers of poles. It is only necessary to alter the supply connections from the winding ends 1, 2 and 3 for the larger number of poles, and the winding ends 4, 5 and 6 for the smaller number of poles. With this arrangement the no-load current is decidedly smaller for the small number of poles than for the larger number. These connections are shown in Figs. 4, 5, 6 and 7.

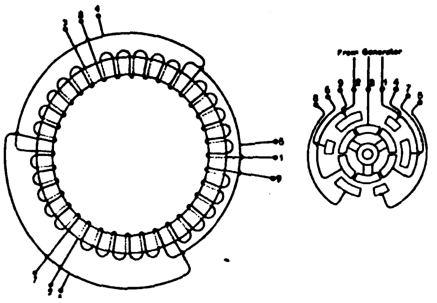


FIG. 3.—DIAGRAM OF CONNECTIONS.

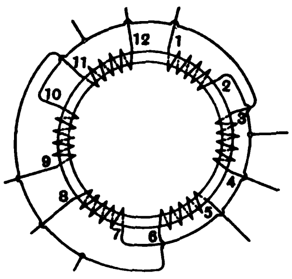


FIG. 4.

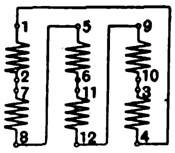


FIG. 5.

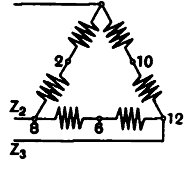


FIG. 6.

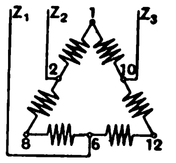


FIG. 7.

By the employment of the new drum windings introduced by the Oerlikon Company, it becomes possible for the designer to adjust the magnetic and electric conditions of the motor to the advantage or disadvantage of one or the other number of poles by making the span of the windings suit one or the other number of poles more or less closely. A series of motors has been constructed for various working conditions with change-overs in the ratios 2: 4, 4: 8, 6: 12, and the simplicity of the system has been fully established in practice.

When employing the previously mentioned drum-winding arrangement with two separate windings, it is easy to increase further the number of speed steps to four without unduly increasing the number of leads. The number of leads for such a motor with four speed steps is 2 x 6, which is no more than for four separate ordinary motors.

The motor is given two separate windings, each of which is suitable for two numbers of poles in the ratio 1:2. The change-over switch itself is a combination of two ordinary three-pole switches. The small number of leads and terminals in combination with the simple, easily inspected winding, similar in every way to the winding of a direct-current armature, forms the principal point of novelty in the system. The direction of rotation and the order in which the different speeds follow one another can, of course, be arranged in any required way. Quite the most advantageous arrangement consists in making the speed vary consecutively from the lowest to the highest value without a change in the direction of rotation. In this way the change from each higher speed to the next lower one takes place almost instantaneously, for the motor, when changed from a smaller to a larger number of poles, acts as a generator pumping current back into the mains until the speed corresponding to the higher number of poles is reached. In general, the leakage coefficient is at least doubled on doubling the number of poles. On this account the starting current of a motor with short-circuited armature, reduced to equal magnetizing currents, is half as large for double the number of poles as for the higher speed, with the favorable result that the motor requires a smaller starting current when started with the smaller speed arrangement than when that for the higher speed is used. This connection can, therefore, be used directly as a starting arrangement for the reduction of the starting current. A considerable economy can be obtained by changing the poles in the case of three-phase motors which have often to be started and stopped, such as haulage or traction motors. On such machines the power expended in starting is known to be of considerable importance. By increasing the number of poles while starting, the power lost in the starting resistances (placed in the induced winding), for a given torque, can be reduced to quarter or half the original value, according as the number of poles at starting is four times or twice as large as the normal. The economy of starting can in this way be made equal to that of the series-parallel control of direct current motors, whilst at the same time employing standard types of motors.

Robinson's Shaft Governor.—A recent number of London *Engineering* contains an illustrated description of a shaft governor devised by A. S. F. Robinson. A peculiarity of the governor is that there are no jointed links, these being superseded by flat springs in order that all joints might be avoided with the consequent wear and tear. The springs which resist the centrifugal force are flat, as shown in Fig. 8, and unlike the ordinary elliptical springs, are stiffer at the ends than at the center. The lower ends of the springs can be set nearer together or farther apart to adjust their tension. The centrifugal arms, *a a*, are carried on pins, *b b*. They are coupled by links, *c c*, the equalizer, *d*, links, *e*, and the shoe, *f*. This shoe is fixed to a spring blade which lies inside of the main spring and is clamped to the other springs. The equalizer *d* has a yoke which can adjust its position if either of the arms is heavier than the other. It has, however, only a limited motion. Springs are attached at one end to the cross-head *g*, which slides on a fixed pin in the governor wheel. By means of the link *h* and the bell-crank *j* (Fig. 9), the motion of the cross-head is conveyed to the sleeve *k* sliding on a governor boss and carrying a grooved coller *l* for the throttle-valve lever. When the governor arms fly out they expand the springs and bring down the cross-head *g*, causing the sleeve *k* to move upwards and partly close the throttle valve. Fig. 11 illustrates a means of altering the normal speed of the engine while it is running, as is often required in electric light stations. The engine shaft *m* ends in a flange to which the solid bladed side of the wheel *n* is bolted. A cover plate *t* is fixed to the end of the hollow sleeve *k*, in which is contained a spindle *s* screwed to a disc *w* fitting the boss end and having a loose collar *x* with a ball race between the two. Next to the loose collar comes a spring *o* which is compressed between it and the plate *t*. The disc spindle *s*, after the sleeve *k* with its cap *n* has been passed through it on to the boss *m*, has a thumb nut screwed on it to come against the sleeve, and at the end of the spindle a hand wheel *h* is fixed. The action of the governor is as follows: When the hand wheel is gripped the ball race enables it and the spindle to be held at rest while the wheel is revolving, and in this position, by pulling out or letting in an adjusting nut *d*, the tension of the spring may be altered and the resistance it gives to the upward movement of the sleeve increased or decreased, thus varying the speed of the engine. Fig. 12 shows how a dashpot may be connected to the governor in case such is necessary, although under ordinary conditions the dashpot is not a necessary adjunct. The sleeve, *k*, and the grooved collar, *l*, Figs. 8 and 9, slide on the boss end of the governor wheel. The engine shaft does not come completely through the boss, but leaves a cavity within it which contains oil and a perforated piston. The end of the boss is fitted with a diaphragm *p*, in which is a stuffing-box through which the piston rod passes for adjustment to the dome-like end of the sleeve *k*. Evidently as the sleeve *k* moves endwise, it will draw the piston over with it and part of the oil will have to make its way through the holes in the piston. Fig. 10 shows a horizontal cross-section.

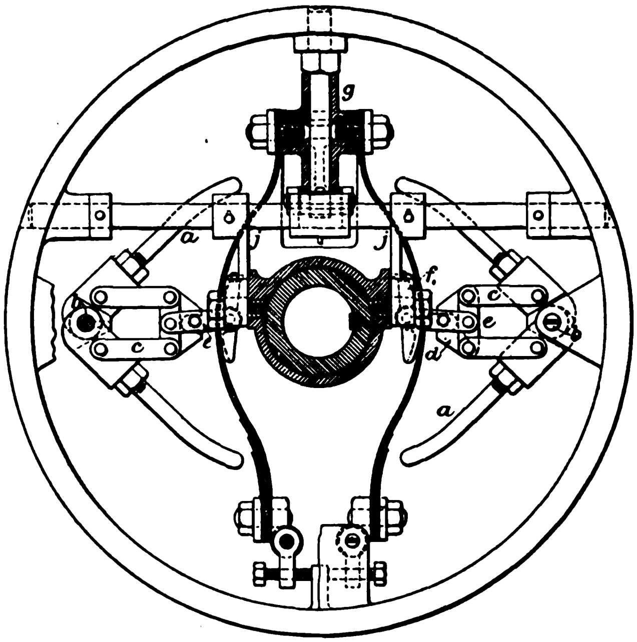


FIG. 8.—ROBINSON'S SHAFT GOVERNOR.

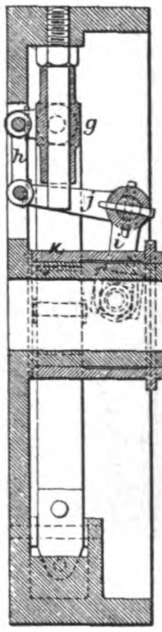


FIG. 9.

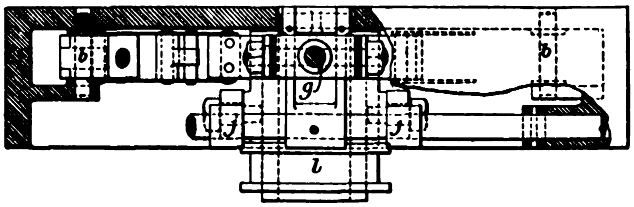


FIG. 10.—ROBINSON'S SHAFT GOVERNOR.

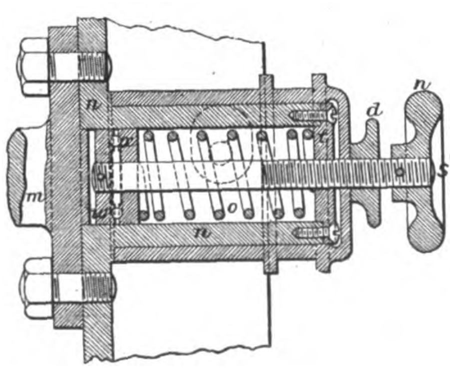


FIG. 11.—DEVICE FOR ALTERING SPEED.

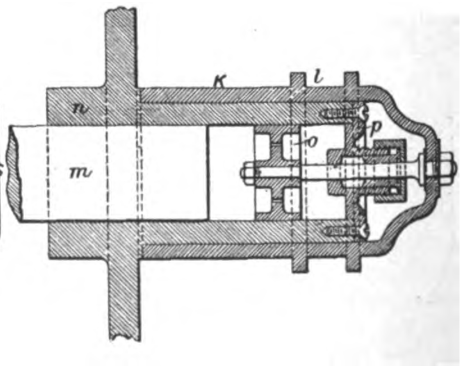


FIG. 12.—DASHPOT.

Railway Section Cut-Out.—A railway cut-out, which the London *Electrical Times* says possesses considerable merit and reliability, is shown by Fig. 13 herewith. A switch is enclosed in a cast-iron chamber or box, arranged to be fastened to the pole. One terminal is connected to the trolley wire and the other to the rail. A contact maker in the form of a cup and ball is suspended in an "off" position by a chain or strong cord passing over an insulated pulley and thence to a metal knob in a pane of glass in one side of the cast-iron chamber. It is plain from the illustration that should any accident happen, such, for example, as a telephone wire falling across the trolley wires, or if the latter should break, it only requires the pane of glass at the nearest pillar to be broken, when the ball contact will drop and short-circuit the trolley wire to earth. The instant result will be that the nearest circuit-breaker or the one at the central station switchboard will be released and the section cut out. It is also impossible for the switchboard attendant to replace the circuit-breaker until the line is cleared. The circuit-breaker fuse on the switchboard which is blown indicates the route on which the accident has happened, and an inspector goes along till he comes to the spot, cuts out the particular section at the nearest section box and permits traffic over the rest of the line to be resumed while repairs are effected on the cut-out section.

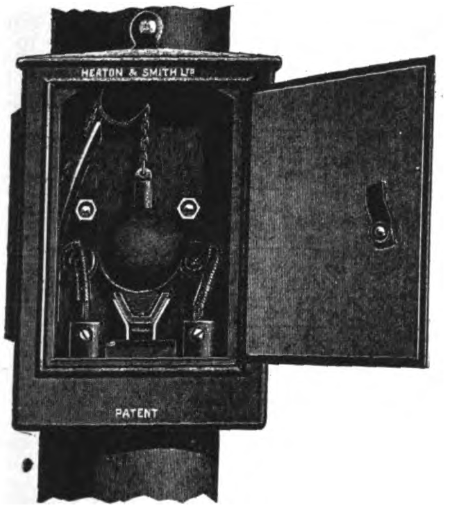


FIG. 13.—SECTION CUT-OUT.

Wrought-Iron Armature Frames for Large Alternators.—According to the *Zeitschrift des Vereins Deutscher Ingenieure,* a rather interesting novelty in alternator construction has recently been put into practice by the Siemens & Halske Co., of Berlin, Germany. This consists of the use of riveted wrought-iron armature frames. Cast iron has been used hitherto as a material for the frames, but as alternators grew larger these narrow large ring castings gave much trouble in machining and erecting. They were heavy, and due to their shape were quite deficient in stiffness, in spite of their cored box construction. As these frames are in general purely structural elements, supporting the laminated core ring on which the armature coils are wound, the use of wrought iron or steel suggested itself as a means of reducing the weight and increasing the strength and stiffness of the frames. Figs. 14 and 15 show two examples of wrought-iron frames. That represented in Fig. 14 is for a very large alternator, the bore of the armature being 19 ft. 8 in., and the width of the core about 9 in. To the left is shown in section a cast-iron frame for this size of machine, while to the right is the corresponding wrought-iron frame. The difference in the amounts of metal required for the two constructions is apparent. As will be seen, the wrought-iron frame is in effect an annular box girder following closely the box-shaped section of the cast-iron frame. The frame is riveted up of plates and angles in the same manner as regular structural steel work. The method of supporting the laminated core ring should be noted. The core punchings are firmly bolted between two rings of angle and plate and the whole core ring is then hung in the main frame by bolts with double nuts, so that it can be accurately centered and adjusted. The section of frame shown in Fig. 15 is designed for a much smaller machine. The load to be carried is here so small that the box construction is not required, sufficient stiffness being given by bent channel iron riveted to the outside of the main ring plate. The support of the core ring is similar to that used in case of the wrought-iron armature frame illustrated by Fig. 14.

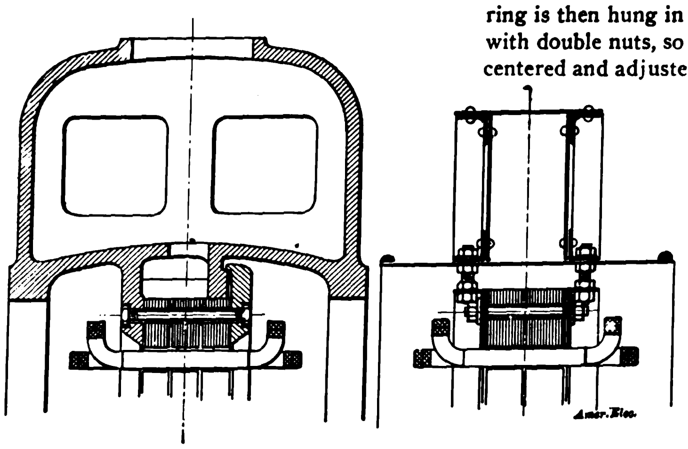


FIG. 14.—WROUGHT IRON ARMATURE FRAMES.

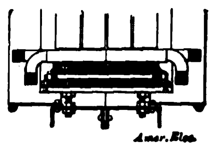


FIG. 15.

Some Recent Electrical Patents

Arc Lamp Carbon.— In the manufacture of arc lamp carbons the addition of coloring and light-producing salts to a carbon base in order to enhance the luminous efficiency of the arc has been repeatedly tried but without any great measure of commercial success. The principal objection to carbons of this sort that have thus far been made lies in the fact that when the composite carbon is heated its salts, in melting, produce scoriæ abundantly, which either drop from the carbon or obstruct the arc. This objection is particularly noticeable when the composite carbon is the upper one of the two. Figs. 1 and 2 herewith illustrate forms of composite electrodes which have been devised by Professor André Blondel, of Paris, with a view to overcoming this difficulty. The main body of the electrode is formed of carbon combined with the salts of calcium, magnesium or similar light-producing salts, and it is enclosed in a very thin shell or coating of non-scorifiable carbon consisting of either pure carbon or carbon that is combined with such a small percentage of the light-producing salts as to practically eliminate scorification. This outer coating protects the main body of the electrode from being superficially burned or licked by the flame of the arc. Fig. 1 illustrates a simple composite electrode with its outer coating of carbon, and Fig. 2 illustrates the cored form of electrode in which the core, *d*, consists of alkaline salts, such as tartrates, carbonates, borates and silicates of sodium, potassium, etc. The inventor states that in practice he has found the best proportions to be 7 millimeters (.275 inch) diameter for the body, *a*, whether cored or solid; 2 millimeters (.078 inch) diameter for the core when one is used, and a thickness of 1 to 2 millimeters (.039 to .078 inch) for the outer coating. The body, *a*, is formed on a paste containing about equal quantities of carbon, such as is used in the manufacture of ordinary arc lamp electrodes, and of fluoride or phosphate of calcium; the outer coating, *b*, is of pure carbon and the core, *d*, is made of the alkaline salts used ordinarily in making low-voltage and cored carbons, the salts of potassium being preferred. The body of the carbon

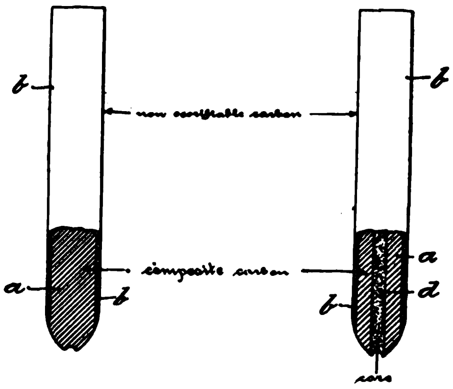


FIG. 1.—ARC LAMP CARBONS.—FIG. 2.

may be made according to the usual European method, by forcing through a drawing plate a paste consisting of not less than 10 per cent nor more than 90 per cent of carbon and the remainder of rare earths, such as salts of calcium, magnesium, thorium, etc., combined with tar under pressure. The pencils are then dried and baked at a temperature sufficiently low to avoid volatilizing the salts. They are then put through a press in which the outer coating of carbon combined with tar is pressed on the composite carbon, and the whole is baked again. The press used in applying the tar coating is similar to that used in covering cables with a sheathing of lead. Patent 714,277.

Booster. — In the practical operation of boosters for electric circuits it is in most cases important that the boosting effect should vary as nearly as possible in proportion to the variation of current in the booster-circuit. This result, however, is difficult of attainment, due first to the residual magnetism of the magnetic circuit of the booster and also to the droop of the saturation curve of the magnetic circuit as the current through the booster approaches full load. The residual magnetism causes the boosting effect to be greater in proportion toward no load than toward full load and even to have an appreciable value on open circuit. On account of the causes mentioned the external characteristic of the booster represents a more or less considerable boosting effect on open circuit, which boosting effect, however, rises first in nearly a straight line as the load comes on and then commences to droop more or less, depending upon the design of the particular machine under consideration. In boosters having a characteristic curve of the kind described, therefore, it is evident that if the boosting effect is adjusted so as to be correct at full load it will have an unduly high value at half load and below. A method of obviating this difficulty, which has been patented by H. F. T. Erben and Arthur F. Knight, is illustrated diagrammatically by Fig. 3 herewith. Referring to the engraving, *8* indicates the armature of the booster and *7* is the motor armature which drives it. The motor is provided with an ordinary shunt-field winding *12*, and a rheostat *13*, the latter in series with the entire motor. The booster is provided with a series winding, *9*, which excites the field in the ordinary manner, and a differential shunt winding *10*, in series with which is a rheostat *11*. The differential winding is so designed and its current is so adjusted as to produce just sufficient magnetizing effect to eliminate the residual magnetism in the booster field-magnet at no load. The result is that the characteristic curve of the booster rises from a point near the origin, thereby causing a reduction of the boosting effect in the neighborhood of half load, but not reducing perceptibly the boosting effect at full load; a small magnetomotive force having very little effect upon the field saturation at this point of the curve. Patent 712,052.

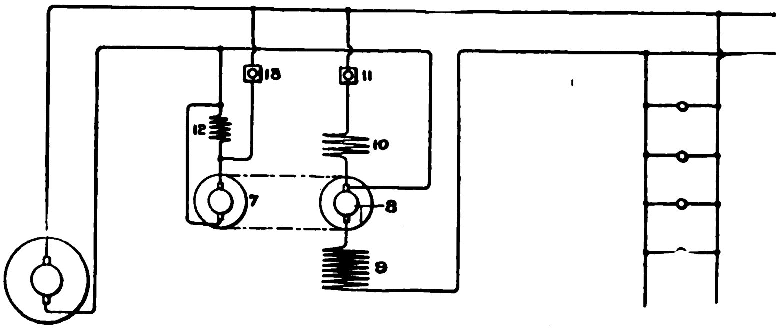


FIG. 3.—DIAGRAM OF BOOSTER WINDINGS AND CONNECTIONS.

Vibrating Interrupter.—It is well known that the secondary e.m.f. of an induction coil is dependent upon the rapidity of changes in the primary current; an interrupter or vibrator giving a quick, clean break, produces, therefore, a greater secondary effect than a sluggish one. Having this principle in mind, Lars G. Nilson, of New York, has devised and patented a combined interrupter and magnetic blow-out, the arrangement of which is clearly shown by Figs. 4 and 5 herewith. The vibrating member, *5*, is a thin strip of non-magnetic spring material, and is actuated by means of an electromagnet, *1*, distinct from the induction coil; the latter is indicated conventionally at *14*. The spring strip, *5*, carries two shoes of magnetizable material, *6* and *7*, which are attracted by the magnet poles, and form secondary poles between which a magnetic field is set up that extinguishes the spark formed at the contacts, *8* and *9*, upon opening the circuit. It is obvious that the individual interrupter magnet is rendered necessary by reason of the need of bipolar construction to effect the quickest destruction of the arc. Patent No. 714,020.

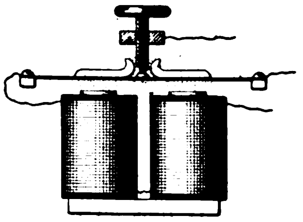


FIG. 4.—VIBRATING INTERRUPTER.

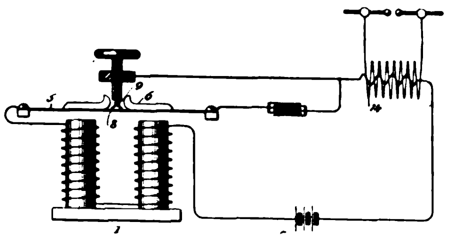
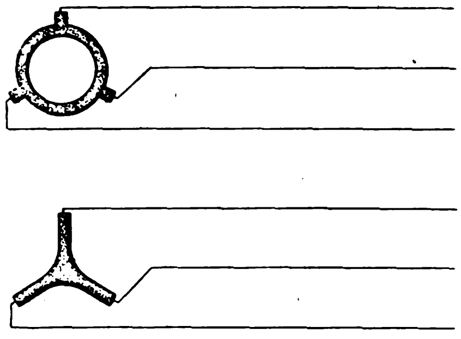


FIG. 5.—VIBRATING INTERRUPTER.

Three-Phase Nernst Lamp Glower.—Figs. 6 and 7 illustrate an invention so simple that no explanation of its character, beyond the engravings and the title, is actually necessary. The object of the inventor, Riccardo Arno, of Milan, Italy, is to provide a lamp that shall inherently balance the three legs of a three-phase alternating-current circuit, and thus render circuit manipulation at the switchboard unnecessary so far as symmetrical division of the load is concerned. Fig. 6 shows the delta-connection glower, and Fig. 7 a glower that gives "Y" or star connection. Patent No. 713,586.



FIGS. 6 AND 7.

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NOTES.

Transatlantic Wireless Telegraphy. —According to a despatch from Mr. Marconi, dated at Glace Bay, Nova Scotia, December 21, and received at the office of the Associated Press in New York city, wireless telegraph messages have been transmitted from the Governor-General of Canada to the Kings of Great Britain and of Italy.

Chicago Electrical Association.—At the next meeting of the Chicago Electrical Association, which will be held Friday evening, January 16, Mr. H. M. Brinckerhoff, general manager of the Metropolitan West Side Railway Company, will deliver a lecture on third-rail electric railway systems. The association recently elected officers for the current year as follows: President, Prof. P. B. Woodworth; vice-president, Peter Junkersfeld; secretary, W. B. Hale; treasurer, H. G. Dimick; auditor, DeW. C. Tanner; directors, W. J. Warder, Jr., C. W. Whitney, Albert Scheible.

Manhattan Elevated System Leased. —Considerable surprise was occasioned during the past month by the announcement that the boards of directors of the Manhattan Elevated Railway Company and the Interborough Rapid Transit Company had authorized the lease of the Manhattan system to the Interborough Company for a period of 999 years, on the basis of a guaranteed dividend of 7 per cent. on the Manhattan Company's stock. The lease will take effect April 1, 1903, and it is devoutly to be hoped that the public will be benefitted by the change in management. It is difficult to conceive, however, that any change other than an improvement could occur.

Combination of German Manufacturers.—According to cable dispatches from Berlin, the combination of several large electrical manufacturers was projected recently for the purpose of underbidding American manufacturers on account of the keen competition of the latter. It was originally the idea to combine the Allgemeine Elektricitäts Gesellschaft, the Union Elektricitäts Gesellschaft, the Schuckert Company and the Siemens & Halske Company, but as finally consummated the combination includes only the Allgemeine and the Union companies. The Siemens & Halske Company, which is the largest institution outside of the combination, held its annual meeting recently and declared only a 4 per cent dividend; the dividend for 1901 was 8 per cent. The company's report states that the establishment is thoroughly able to go on independently of the combination, but that after the situation clears up it may become feasible to join its interests with those of the two companies now combined.

Engine Builders' Association.—The fifth semi-annual meeting of the Engine Builders' Association of the United States was held at Sherry's, New York, on December 1; Mr. W. M. Taylor, of the Chandler & Taylor Company, presided. Four papers were read, the titles and authors of which were as follows: Superheated Steam, by Ernest Foster; High Pressure Steam Piping, by William Andrews; The Early History of the Corliss Engine, by George R. Phillips, and The History of the High-Speed Engine, by Professor John E. Sweet. Very full abstracts of the first two papers are published elsewhere in this issue. There was a short discussion of Mr. Foster's paper by Messrs. S. B. Payne, W. C. Kerr, Thomas C. Wood and Professor John E. Sweet, which brought out no new points beyond the statement by the author to the effect that no difficulty in lubrication is experienced with superheat not exceeding 500 degrees Fahr. In the discussion of Mr. Andrews' paper the author emphasized the importance of installing close to the throttle valve a receiver having a cubical capacity three times as great as that of the engine cylinder. This, he pointed out, makes possible the use of comparatively small pipes to supply the engine, insures higher initial steam pressure in the cylinder and reduces the shock due to the interruption of the flow of steam by the closure of the admission valve.

Professor Sweet in his paper related some interesting recollections of the early days of high-speed engine building, beginning about 1862 with the Allen engine. A large part of the paper was devoted to a discussion of this engine and its commercial development at the hands of Mr. Charles T. Porter. The chief feature of Mr. Phillips' paper was a biographical sketch of George H. Corliss and an account of his various business connections and the conflict of the Corliss and Sickles interests.

At the business meeting, held on the afternoon of December 2, the election of officers for the ensuing year was held. Mr. W. M. Taylor was re-elected president; Mr. C. A. Gates, vice-president; Mr. F. P. Ide, secretary, and Mr. C. S. Bonsall, treasurer.

Interstate Independent Telephone Association.—The second annual convention of this organization was held in Chicago, December 9, 10 and 11. The Association now includes independent companies in the states of Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio and Wisconsin, and the convention was well attended by delegates from all of these states. An animated discussion was incited by a motion made by B. F. Wasson, of Clinton, Ill., to exclude from membership in the association all companies using the Bell transmitters or receivers. Some members were opposed even to allowing any company to hold membership which transacted any business with the Bell Company in the way of toll-line connections, while others claimed that inasmuch as toll-line connections could be made only through the Bell Company in some cases, independent companies having such connections should not be excluded. The question was finally referred to a committee for thorough consideration. The discussion of this question, the reading of several addresses and the transaction of routine business occupied the whole of the first day.

On the second day of the convention Mr. George N. Bandy, of Des Moines, read a paper on measured service, in which he expressed the opinion that the majority of subscribers to independent exchanges would welcome a change from the present flat rate system to a meter system in which the subscribers would pay for the exact amount of service rendered, over and above a certain minimum number of calls per month. Mr. Bandy conceded that the present apparatus for recording calls had probably not been brought to the state of perfection necessary for the general adoption of such a system, but stated his belief that an instrument that would fully meet the requirements would soon be developed, if demanded.

A paper on the "Sliding Scale of Rates" for telephone service, by Dr. H. S. Herr, was read in his absence by his daughter, Miss Herr. The author pointed out that the telephone business could not be considered in the same light as an ordinary commercial business, such as that of a hardware or grocery store, in which the cost of doing business per dollar of sales grows less and less as the business enlarges, and advocated a sliding scale of rates for telephone service, based upon the number of connections given to subscribers in any one system. This sliding scale, he said, should necessarily vary with the conditions under which the service is rendered. For small companies which do not need to use tall poles, aerial cables or conduit work, the rate for a given amount of service can be lower than in cities where these classes of construction are required. He expressed the opinion that no exchange of 500 telephones or less can do business successfully under the most favorable possible conditions at a rate averaging less than $1.50 per month for every telephone; this average is usually accomplished by charging $1 for residence instruments and $2 for business telephones. Beyond 500 subscribers, it is necessary to advance the rate by a small percentage as the number of subscribers increases. He cited reports received from several independent companies which placed the number of telephones with which these rates could be made profitable at 400 to 500; one company, however, made the maximum number 800, and another 250.

Mr. Glanden, of Pike County, Illinois, said that he had used the sliding scale in exchange work in his county with great success. His plan was to start a rate of 50 cents per month for each subscriber until the number of subscribers exceeded 50. As soon as this number was exceeded the rates were raised 1 per cent per month for each additional subscriber.

In a paper on toll-line rates, Mr. H. H. Robinson, of the United States Telephone Company, reviewed the history of long-distance rates and described the manner in which the initial rate system was devised.

Upon invitation from Prof. W. E. Goldsborough, Chief of the Electrical Department of the Louisiana Purchase Exposition, the Association resolved to hold its 1904 meeting at the St. Louis Exposition grounds, the date of the meeting to be decided later by the executive committee.

Mr. A. L. Hutchinson, of Weyauwega, Wis., read a paper favoring the establishment of a clearing house in each state for checking up toll-line messages between each of the companies and making out balance sheets at regular intervals showing the amounts due from each company to each of the other companies concerned. Col. J. D. Powers, of Louisville, Ky., then read a paper on independent telephone securities as an investment, in which he discussed this question from the banker's standpoint. The delegates manifested enthusiastic approval of the sentiments and opinions expressed in the paper, which was too long and too comprehensive to admit of being outlined or abstracted.

Mr. J. J. Nate, of the Stromberg-Carlson Telephone Manufacturing Company, who is one of the pioneers of the independent telephone movement, read a long and interesting paper on the Berliner patent and the Bell Company's claims of infringement, which also included a discussion of the various points in patent litigation now pending. A resolution presented by Mr. C. B. Doble, declaring against the purchase by any independent telephone company of any apparatus from the Western Electric Company because of its control by Bell telephone interests, was carried, and a paper by Mr. Charles E. Hull, on "Suggested Methods for Improving Long Distance Telephony," was read. Mr. Hull condemned the haphazard manner in which so many independent exchanges have been built, and offered practical suggestions for securing much-needed "local" long-distance communication rather than purely long-distance service.

The election of officers resulted as follows: Charles E. Hull, Salem, Ill., president; L. A. Frazee, Connorsville, Ind., vice-president; E. M. Conklin, Louisville, Ky., secretary, and J. W. Layne, Carthage, Mo., treasurer. The executive committee named by the State delegates consists of H. S. Herr, Iowa; W. G. Jones, Ohio; A. L. Hutchinson, Wisconsin; E. H. Moulton, Minnesota; A. B. Conklin, Illinois; W. T. Hall, Missouri; W. D. Pruitt, Kentucky; O. Rex, Indiana, and J. B. Ware, Michigan.

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CONTENTS.

A Large and Modern Isolated Power Plant.... 1
Superheated Steam, by E. H. Foster.......... 11
The Operation of Machine Shops by Individual Electric Motors, by R. T. E. Lozier.......... 12
Determination of Induction Motor Characteristic Curves, by A. S. McAllister................. 15
High Pressure Steam Piping, by William Andrews.......... 17
The Three-Wire System for Variable-Speed Motor Service, by N. W. Storer................. 18
American Practice in Electric Motor Construction.......... 20
Abstracts from Foreign Contemporaries........ 40
Some Recent Electrical Patents............... 43
Notes.......... 44
Editorial.......... 46
Design for an Electric Runabout, by J. C. Brocksmith.......... 48
Heating and Ventilating by Forced Blast, by C. L. Hubbard.......... 55
Direct Current Motor Wiring, by P. C. Percy. 57
A Few Points in Motor Operation, by G. W. Malcolm.......... 60
Lessons in Practical Electricity............... 61
Letters on Practical Subjects............... 62
Electrical Catechism.......... 64
Queries and Answers.......... 65
Making and Laying a 500-Mile Cable.......... 66
Test of the Clare Storage Battery............ 68
Line Wire Transposition.......... 68
New Apparatus and Appliances............... 69
Legal Note..........Adv. 75
Personal..........Adv. 75
Trade Publications..........Adv. 75
Business News..........Adv. 76

New Year's Greeting.

Once more the American Electrician extends the greetings of a holiday season to its readers, and earnestly wishes them all a Happy New Year signalized by unbounded prosperity. The past year has been a phenomenal one in the electrical industry—in fact, in almost every avenue of trade—and we trust that the engineers, manufacturers and dealers whose technical skill, vigorous enterprise and business sagacity have contributed so largely to the remarkably prosperous conditions may long continue to reap the adequate reward merited by their able efforts.

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Electric Motor Construction.

The article descriptive of American motors which appears in another part of this number should be of much interest to everyone concerned with the operation of stationary electric motors, as well as to those engaged in the manufacture of such machines. Although the author of the article was unable to present all of the features of every machine, and was obliged by the absence of data to omit descriptions of a few makes, the article constitutes an excellent review of American practice and affords an unusual opportunity for a study of the motors of different builders. It also serves to emphasize the remarkable uniformity of direct-current motor design which prevails in this country, so far as purely constructional features are concerned. There is only one multipolar machine (the Perret) that is not built with a circular field-magnet yoke, and only two (Lundell and Storey) that do not have strictly radial magnet poles. Among the bipolar motors, only three are built with other than circular field-magnet yokes.

Of course, the external contour of a motor has little to do with its running qualities, but it does affect in good measure the cost of construction and the degree of protection readily available for the most vulnerable parts of the machine. However, the circular yoke is by no means the only, or even the chief, feature of uniformity in American motors. Form-wound and individually-insulated armature coils have made the multipolar machine almost invincible so far as damage to the armature winding goes, and this has been in years gone by one of the weakest points in direct-current construction. Almost unanimous practice also is noticeable in the frame design of machines of medium and large sizes. The magnet yoke-ring is either bolted to a base that is cast in one piece with the journal pedestals, or else it is cast integrally with the base, and one or both of the journal pedestals bolted on. There are very few exceptions to this rule.

The requirements in the design of induction motors are such that no conspicuous divergence from a stereotyped construction is practical. The metal parts of the magnetic circuit must, of course, be composed wholly of laminated material; the field structure must, for decent efficiency, be of the slotted ring type (that is, without definite structural poles), and the rotor, while its construction may be varied within slight limits, is not improved by radical departures from the accepted form. It is noteworthy, however, that the machines built in this country invariably have partially-closed conductor slots in both the stator and rotor, while many European machines are built with entirely closed slots, or more accurately, holes for the conductors.

The features in which American machines are most uniform, however, and which are the most gratifying ones, have not been brought out in the article, not being susceptible of convincing demonstration in print; these are the high class of workmanship and excellent efficiencies which characterize not only motors but all other American electrical apparatus involving the application of engineering ability and judgment.

◆◆◆

Electric Motors in Shops.

Very little argument is required now-a-days to convince the owner of a machine shop or other establishment containing a large number of machines that the electrical distribution of power is the most desirable method thus far developed. The problem is not so much whether electric motors shall be used or not, as the manner of their application. Elsewhere in this number will be found two articles relating to this phase of the question, which are timely and contain much practical information.

One writer, Mr. Lozier, gives figures showing how the cost of power with individual motors compares with the cost of power for motors driving groups of machinery, the total output of the shop being the same, of course. These figures make a very attractive showing for the individual motor, but unfortunately the comparison is incomplete in that the first cost of the motor equipment is not given. There is a very considerable difference between the fixed charges on a plant of ten 10-h.p. motors, for example, and those on a plant of say twenty 5-h.p. machines, and in many cases this is the determining factor. It is perfectly obvious to anyone familiar with manufacturing methods that the individual motor drive is the very best practicable method for machines that have several running speeds and are not in operation constantly, provided the operating cost compares favorably with that of grouped machines. The workman has much greater facility and a far better range of speed control with multiple-speed individual motors than under any other system.

The method of speed control for multiple-speed motors is an interesting and somewhat perplexing question. The well-known three-wire system of current supply described by Mr. Storer is a fine one, but we confess to a total lack of enthusiasm regarding the method of speed control described in connection with it, in view of the practicability of obtaining the same results with lighter motors and without the use of idle resistance coils in the armature circuit. The objection to external resistance is not so much on account of the waste of energy, which does not amount to any great loss in dollars, as to the space occupied by the coils and the increased liability to interruption of the individual service that they entail. It would seem that a double-commutator armature winding, with a moderate series field winding for starting and a shunt field winding of variable strength for running, would be preferable to the external armature resistance and the extraordinary range of shunt field excitation described in the article under discussion. A motor of this sort operated on the three-wire circuit would have four speeds at maximum efficiency and four speeds at maximum torque, while the range of field excitation would need to be only one-half that required by the single-commutator machine to produce the same total speed range.

One of the greatest advantages of individual motors in machine-shop operation is the ease with which changes in speed may be effected. It is the practice of at least one manufacturer to mount the controller handle on the carriage of a lathe, so that the workman may adjust his speed without moving a step from his working position. While this may appear to be a sort of academic refinement to anyone familiar in only a general way with machine tool operation, it is a fact that the saving in time by the arrangement amounts to an astounding figure in the course of a year's operation on a long lathe. The only serious disadvantage involved in the use of individual motors is the increase in fixed charges—interest on the equipment. The saving in the cost of power, as compared with a group of machines driven by one motor, will not usually offset the increase in fixed charges. It is ordinarily negligible for the reason that in most shops the total cost of power under the worst practical conditions is only two or three per cent of the cost of production. It is the increased facility, not the power saving, that counts.

The Manhattan Elevated Railway Fiasco.

It is an aged truism that it is vastly easier to tell a man how a thing should be done than to do it; it is also an anciently established fact that an onlooker at any game or other proceeding requiring nimble wits and accurate foresight usually obtains a much more comprehensive grasp of the situation at any stage of the proceeding than does a participant. But, however apposite these two facts may be in most cases of volunteered assistance from outsiders, they fail lamentably when proffered in extenuation of conspicuous inefficiency such as that which characterizes the traffic management of the Manhattan Elevated Railway Company. The service on the lines of this company has been steadily deteriorating for a number of years, and during the past month it has been of such a nature as to inspire in the most amiable and invertebrate patron of the road a feeling of resentment toward the management that might readily find outlet in personal violence under favorable circumstances.

The absolute collapse of every vestige of systematic service was precipitated by the first sleet storm of the season early in December, and since that time the service has been utterly demoralized. Between the hours of 7:30 and 9 a. m. and of 5 and 7 p. m., it is impossible to predict the length of time that will be consumed in traveling over distances that have been covered time and time again in twenty minutes, in former years; one may waste anywhere from half an hour to two hours on such a trip. The contention that such a state of affairs is due to growth in traffic is sheer nonsense; the patrons of the elevated lines have not doubled within the past thirty days, and yet the number of people that now fight daily for access to trains during the rush hours is fully double the number that was packed on the platforms a short time back—merely because the accumulation is not relieved as promptly as it should be.

The oft-reiterated claim of the management that no more trains can be run has somehow a hollow sound when one recalls waiting on a station platform from four to eight minutes for a train, as the present writer has done several times recently. Another feature which does not tend to establish a reputation for intelligent management is the practice of holding an express train at the point where it must switch over to the local track, so as to allow a local train abreast of or even behind it to crawl on ahead of it because, forsooth, the "schedule" —which cannot be and is not adhered to for any length of time after trains leave the starting point of a "run"—specifies this order of progression.

The manner in which the Manhattan conductor rails are mounted has been the subject of much comment on the part of persons zealous in offering well-meant but wholly superfluous advice, but in view of the successful operation elsewhere of third-rail systems in trying weather and with rails mounted similarly to these, there is not much chance to shift blame to the shoulders of the engineers. The guard timbers on each side of the conductor rail are so close to the rail as to form an excellent pocket for snow and debris, but this is about the only serious error in engineering judgment that has thus far developed. It is feasible, of course, to shelter the conductor rails from the weather, but this would involve very clumsy construction in both the collector shoe and the roadway, and it is not actually necessary. About the only real need of the Manhattan system appears to be a liberal supply of "horse sense" in the traffic department.

Neglected Sources of Information

It is surprising, not to say disheartening, to note the supine indifference with which engineers and scientific investigators treat the splendid opportunities for learning that are offered by the daily press. For example, the New York *Times* announced last week the remarkable discovery that the single-phase alternating current "dispenses with costly transformers" and permits the "transmission and direct utilization of currents of high potential by much simpler and cheaper mechanism" than—than—well, the writer did not say than what, but that is an insignificant detail. That single-phase alternating current, in contradistinction to polyphase alternating currents, may be transmitted and utilized at high potentials without the use of transformers is a revelation second in importance only to the enunciation of Newton's law; yet we venture to predict that alternating-current engineers will pass it by with stolid inattention.

DESIGN FOR AN ELECTRIC RUNABOUT.

BY J. C. BROCKSMITH, M. E.

The vehicle here described is of the light runabout type, capable of seating two persons, and is of the simplest and lightest construction that can be used consistent with durability and good running qualities. A double-motor equipment has been adopted, thus avoiding the use of a differential or balance gear and allowing the motors to be made smaller and therefore more easily constructed by the amateur builder. The use of two motors also makes possible a greater range of speeds by means of series-parallel control than could be obtained with only one motor.

The power is derived from a 20-cell battery having a capacity of 60 ampere-hours, and the vehicle is designed for a normal full speed of 14 miles an hour on level asphalt with two passengers (300 pounds). This requires a current consumption of 20 amperes at 40 volts, and the battery has sufficient capacity for a run of 30 to 35 miles at this discharge rate.

The controller provides three normal forward speeds of 5, 10 and 15 miles per hour, and a slow speed reverse of 5 miles per hour. In addition to this an "accelerator" is provided which can be used on any of the regular speeds, thus increasing the available speeds by any percentage that may be desired, and giving in reality six forward speeds and two reverse speeds. Higher speeds than the normal are only obtained, of course, at the expense of efficiency, which means a lower mileage capacity, due to the higher discharge rate of the battery. The outfit is designed practically for city use, where good roads and charging facilities may be found on every hand, and with this in view the weights of the various parts have been reduced to the lowest possible figures. The approximate weights of the various items and of the complete vehicle are as follows:

The two motors, 40 lbs. each	80 lbs.
Battery, 20 cells	190 lbs.
Battery trays	30 lbs.
Running gear, body, etc.	150 lbs.
Total for complete vehicle	450 lbs.

Fig. 1 shows a side elevation of the automobile, from which it will be noted that the motors are pivoted to the rear axle, which is stationary, and are spring suspended from the frame in front, being direct-geared to the rear hubs, with a gear ratio of 7. The wheels are 28 inches in diameter, provided with 2½-inch pneumatic tires and 40 spokes of Nos. 9 and 11 gauge.

The body is of the standard "piano box" type, 23½ inches by 56 inches outside measurement, and has a spindle seat. The builder can secure such a body in the white from any carriage maker at such a low figure that it would hardly seem advisable to attempt the construction of it; but for those who wish to build the body themselves, the drawings will supply all necessary dimensions.

The battery, as will be seen in this figure, occupies a space of only 18 inches directly underneath the seat and thus leaves the entire rear portion of the body free for the stowing of parcels, luggage, etc.—a feature which is not found on many automobiles.

The controller which appears in this figure, is a small cylindrical affair, 4 inches in diameter and 9¼ inches high, fastened to the floor of the vehicle directly in front of the seat. The steering rod passes up through the controller and terminates in a steering handle or bar 24 inches above the floor line, while the controller itself is operated by means of a small handle located 4 inches below the steering handle, and secured to a concentric sleeve upon which the contact cylinder is mounted.

The brake pedal is shown in dotted lines, in front of the seat, within easy reach of the operator's foot. This brake acts directly on the tires of the rear wheels and makes a very powerful and reliable brake for emergency stops. For ordinary braking, however, the operator will probably prefer to use his controller handle by turning it to the reverse position.

A volt-ammeter is shown in dotted lines, placed at an angle of 45 degrees against the dashboard. Such an instrument, while not essential to the running of the vehicle, forms a very convenient guide as to the condition of the battery and should certainly be added by the builder if he wishes to have his machine complete in all respects.

A small electric headlight is shown fastened to the front panel of the body and is useful for night driving. The lamp should be about a 6-c. p. 20-volt battery lamp, and it can then be supplied from either section of the battery without interfering with the regular controller connections.

Fig. 2 is a rear elevation of the complete machine which shows the arrangement of the motors, one being geared directly to each rear wheel; this engraving also shows the spring suspension of the frame and body. The semi-elliptic spring which supports the rear of the body is 32 inches from center to center of bolt holes (under a load of 350 lbs.), and is composed of 4 plates 1½ inches wide, the main plate being of about No. 3 gauge steel and the rest of No. 4 gauge. The spring may be drilled and fast-

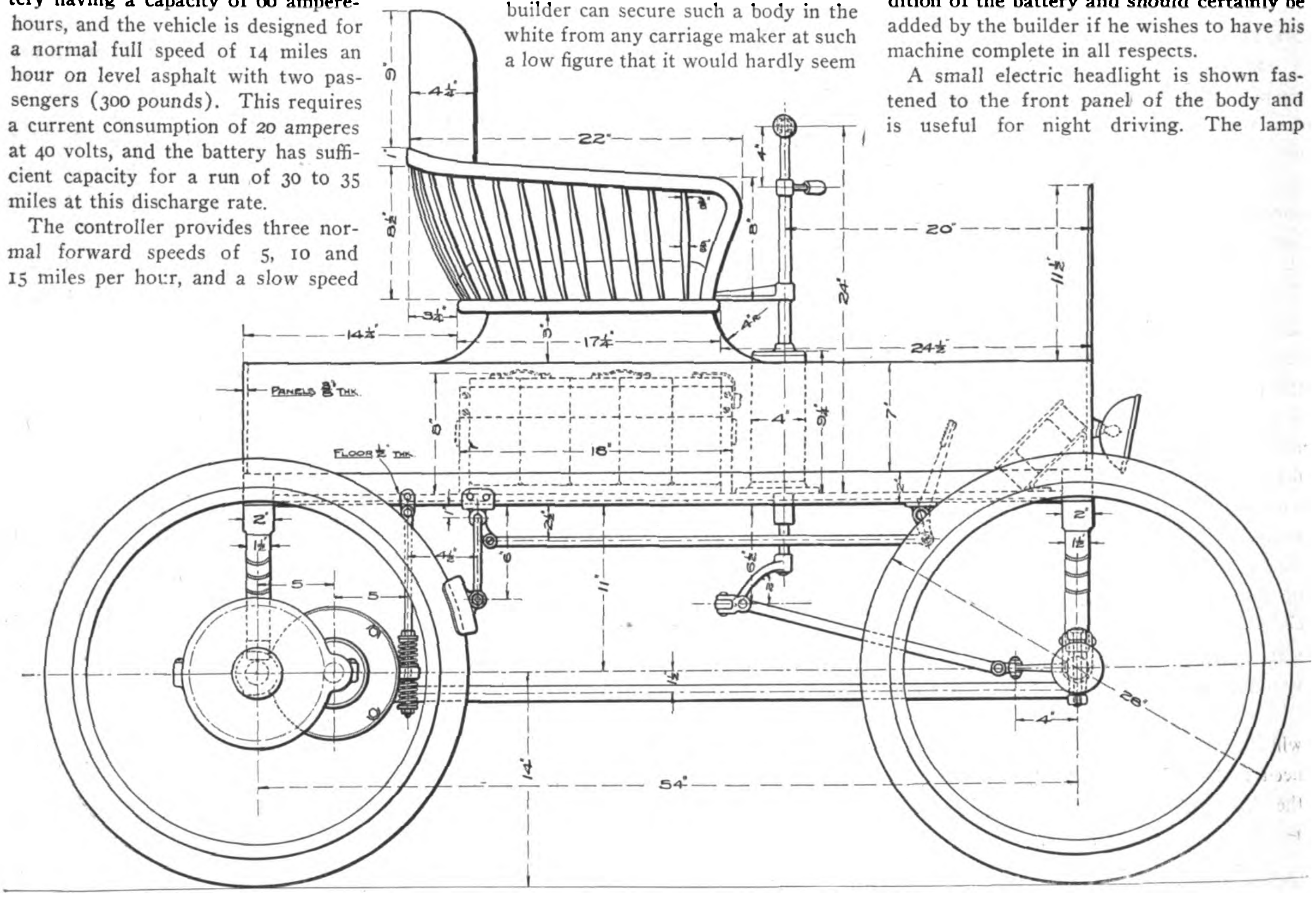


FIG. 1.—SIDE ELEVATION OF ELECTRIC RUNABOUT.

ened to the frame by means of a couple of ⅜-in. x 6-in. bolts as the drawing shows, or clips may be used if preferred. The ends of the spring are provided with holes for ⅜-in. pins or rivets which serve to connect the spring to the fittings mounted on the axle, and which are adapted to allow for deflection of the spring under varying road conditions.

The battery, which also appears in this view, is shown in dotted lines, four trays being placed side by side underneath the seat. When subdivided in this way each section will weigh only about 55 pounds, thus making a convenient unit to handle in case the battery is to be removed from the vehicle for inspection or repairs.

Fig. 3 is a front elevation of the vehicle, and shows the front axle ends, the steering knuckles and their connection to the steering lever. The front spring is of similar construction to the rear one except that it is 36 inches in length, so as to give greater flexibility in the front of the vehicle, where it is most needed. The view also brings out the construction of the frame upon which the body rests. It is built up of a pair of 2-in. x 2-in. x 3-16-in. angles cut off 56 inches long, and bolted at their extremities to a pair of wooden cross bars 2 inches wide, tapering from 1¾ inches deep at the ends to 4 inches deep at the center, and 23½ inches long; these are shaped to fit the curvature of the springs. The flooring is laid directly upon the lower flanges of angles and fastened thereto by means of wood screws. The body itself has, therefore, no bottom, but consists merely of the two side panels, ends and seat, and is fastened to the frame by means of screw clips (not shown) at the four corners. In this way the body may be readily removed at any time, leaving the battery, controller, wiring, etc., *in situ*, and thus affording an easy method of getting at these parts.

Fig. 4 is a detail of the front axle ends. Two of these are required just alike with the exception that one has a ⅜-in. slot 2½ inches long to receive the spring fastening pin, while the other is simply drilled with a ⅜-in. hole. This arrangement is shown in Fig. 3. These axle ends should be soft steel castings and are bored 2¾ inches deep to receive the front axle which is a piece of 1½-in. No. 14 gauge steel tubing 39 inches long. They should be drilled and tapped to receive the 9-16-in. journal pin upon which the steering knuckle turns, and are then pinned in position and brazed securely to the axle, but not before the reach fitting, which is placed at the center of the axle, has been slipped on.

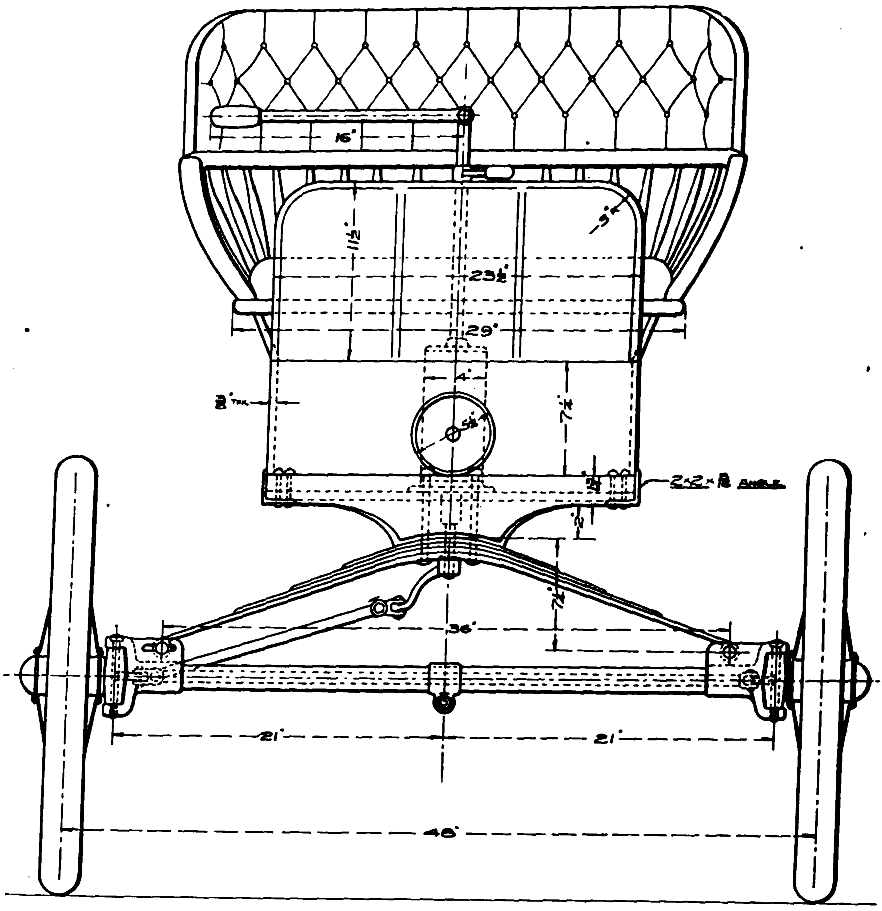


FIG. 3.—FRONT END ELEVATION OF ELECTRIC RUNABOUT.

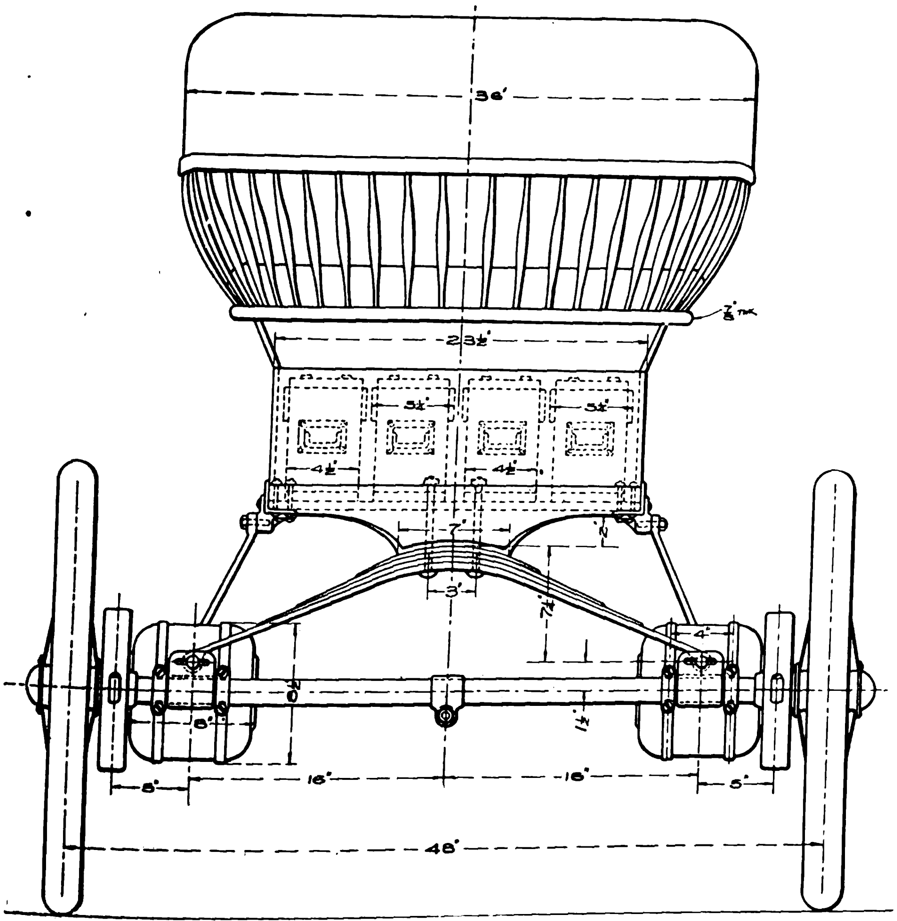


FIG. 2.—REAR END ELEVATION OF ELECTRIC RUNABOUT.

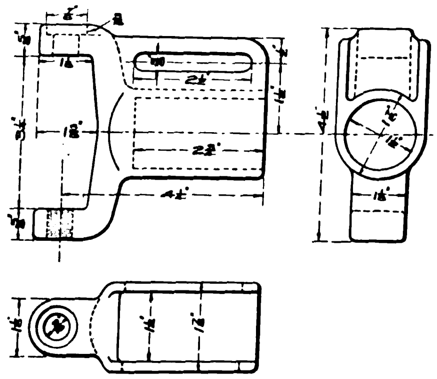


FIG. 4.—FRONT AXLE ENDS.

Fig. 5 is a detail of the front hub, steering knuckle, bearing cones, and journal screw. The hub is shown partly in section to bring out the construction of the ball bearings. Most builders will probably prefer to purchase their hubs and bearings complete, but those who wish to construct their own hubs will find all necessary dimensions given.

The hubs are to be turned from steel castings and are designed to take pressed steel ball cups 1.948 inches outside diameter of No. 12 gauge steel 9-16 inch long, fitted with small brass ball retainers as shown. Each cup contains fourteen 5-16-in. balls. Each hub is to be drilled for 40 spokes, Nos. 9 and 11 gauge—that is, 20 holes, ⅛-in., equally spaced, are drilled through each flange and the holes countersunk.

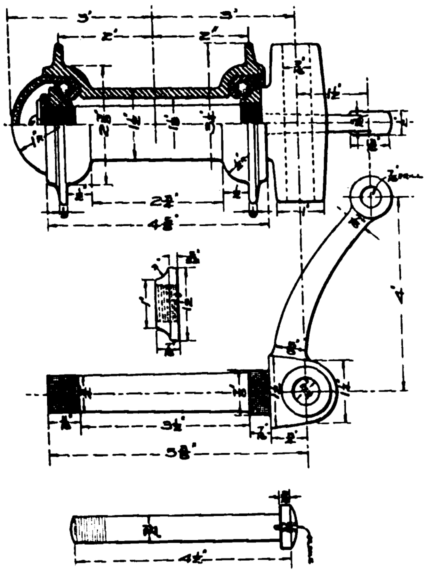


FIG. 5.—STEERING KNUCKLE, HUB, CONE AND SCREW.

The steering knuckle may be a steel casting, or if possible, a forging. The arrangement of the arm which actuates it is to be specially noted. It is inclined to the axle and is also off center of the pivot, there being good reasons for both of these features. Two steering knuckles are required just alike. The journal upon which the steering knuckle turns is a special 9-16-in. screw and can be most conveniently turned from a bar of ⅞-in. cold rolled steel. It is provided with a small oil hole closed by means of a 3-16-in. screw; two are required.

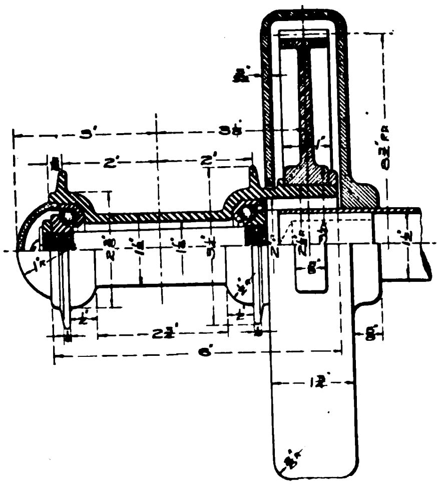


FIG. 6.—SECTION OF REAR HUB GEAR AND CASE.

Fig. 6 is a section of the rear hub, gear and gear case. The rear hub is similar in construction to the front hub, takes the same size ball cups and the same number of balls, but is provided with an extension at the inner end upon which the driving gear is mounted. The gear is 8¾ inches pitch diameter, 12 pitch, with 105 teeth, and is fastened to the hub by means of a ⅜-in. key and set screws (not shown) and is further prevented from endwise motion by means of a locknut 3-16 inch thick which forces it up against a shoulder on the hub.

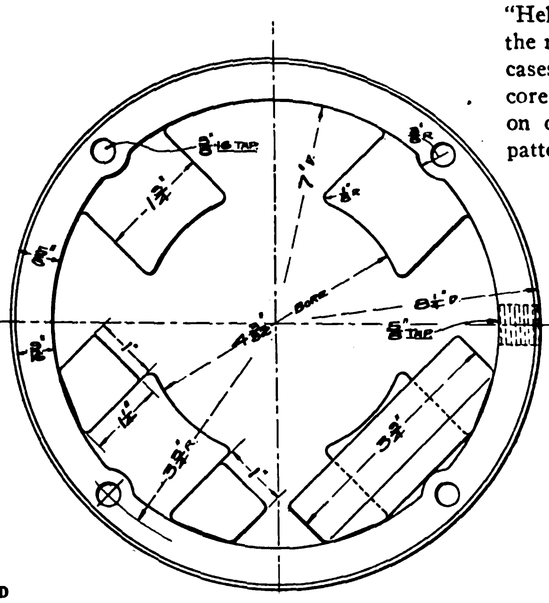


FIG. 12.—END VIEW OF MOTOR FIELD.

Fig. 7 is a detail of the rear axle stub end, two of which are necessary. These pieces are intended to be turned up from a bar of 1½-in. machine steel, threaded to suit the bearing cones and then brazed into the rear axle, which is a piece of 1½-in. No. 14 gauge tubing cut off 43 inches long. Fig. 8 is a detail of the rear axle spring clip. This is a steel casting of which two are required. They may be brazed in position on the axle or they can be fastened with set screws if preferred. They are to be bored 1½ inches to fit the axle, and are provided with ⅜-in. slots for fastening in the rear spring.

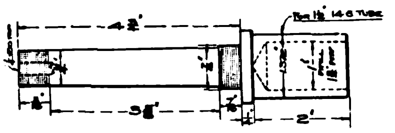


FIG. 7.—REAR AXLE, STUB END.

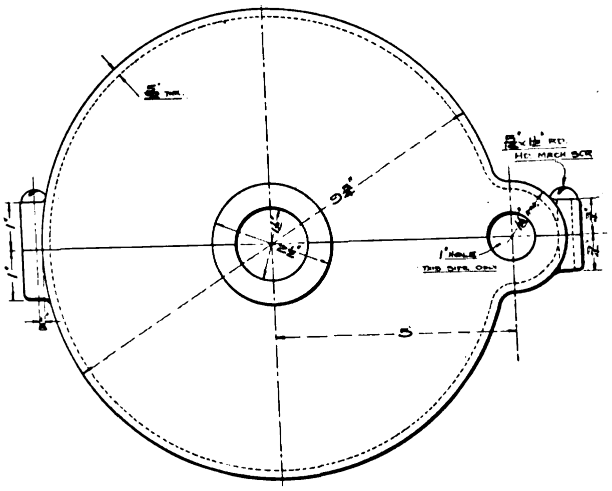


FIG. 9.—SIDE VIEW OF GEAR CASE.

Fig. 9 is a side view of the gear case. It is intended to be cast of aluminum or any of its alloys, and is of 5-32-in. metal, 9¾ inches outside diameter, 5 inches between centers of gears, and 1¾ inches wide outside. This case is intended to be filled with "Helmet" oil, or similar grease to reduce the noise and wear of the gears. Two such cases are required, but a half pattern and core box will do for all, if the 2½-in. boss on one side is made a loose piece on the pattern and transferred from one side to the other during moulding.

Fig. 10 is a detail of the reach fitting. This is a steel casting and two are necessary, one being placed at the center of each axle and connected by a length of 1¼-in. No. 16 gauge tube, 52¼ inches long. The reach is not fastened rigidly to the axles, but the ¾ stub ends, with which it is provided, can turn in the ¾-in. hole in the reach fitting, thus allowing the running gear to adjust itself to the condition of the road.

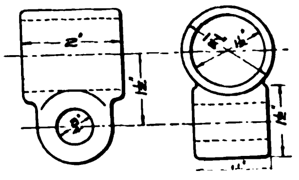


FIG. 10.—REACH FITTING.

Fig. 11 is the steering rod end. This may be either a steel casting or a forging, and the machining necessary on this is simply to bore the hub 9-16 inch for the steering rod and drill the end 7-16 inch for a pivot pin. It should be very securely fastened to the rod preferably by brazing.

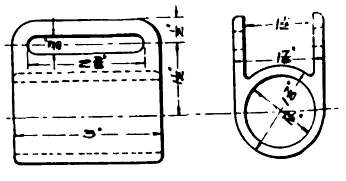


FIG. 8.—REAR AXLE SPRING CLIP.

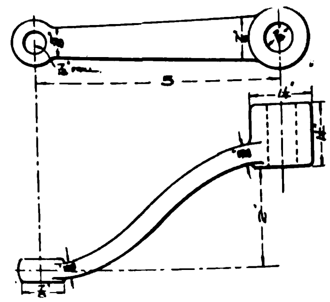


FIG. 11.—STEERING ROD END.

THE MOTORS.

The two motors are exactly alike in construction and give an aggregate of ¾ horsepower at normal load. They may be overloaded, however, when occasion demands, to twice or even three times this amount, without injury. They are each wound for 40 volts and operate at 1,180 r. p. m. with normal gear ratio. They are four-pole machines having a circular yoke and radial poles of soft cast steel in one piece and are provided with cover plates, made of aluminum or any suitable aluminum alloy, which completely encase the working parts. All motor bearings are of the steel ball type in order to reduce friction and wear to a minimum, and the winding is of the ordinary series type.

Fig. 12 is an end view of the field magnet frame. The bore is 4 3-32 inches and the armature core to go with this frame is 4 inches in diameter and has 24 slots each 9-32 wide and 9-16 deep, the teeth being of the ordinary straight form with a slight fillet (of .04 inch radius) at the bottom of the slots. The core is of the usual laminated construction and the discs are to have a one-inch hole in the center and a 3-16-in. keyway.

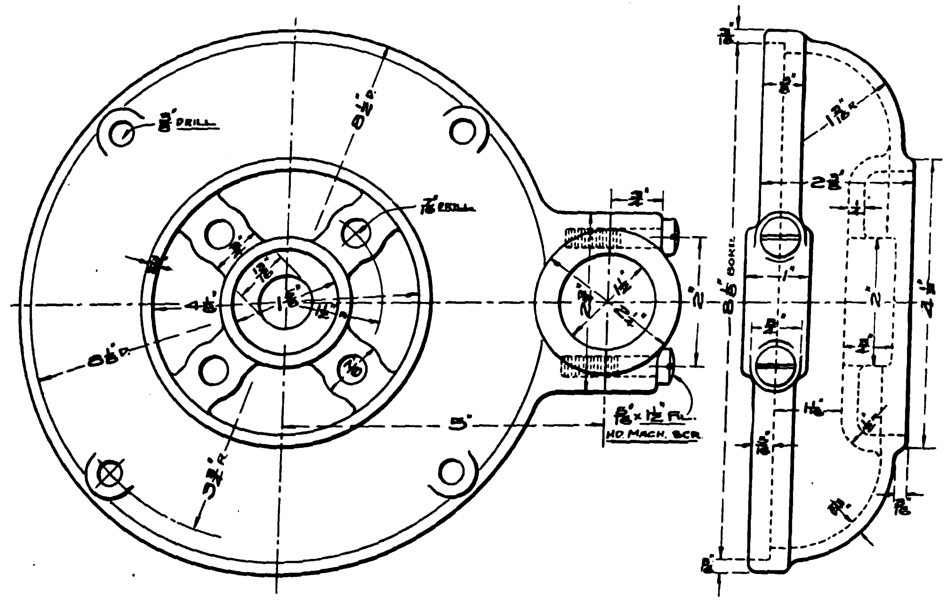


FIG. 13.—END AND SIDE VIEWS OF MOTOR COVER.—FIG. 14.

No pole-shoes are used, the field coils being simply slipped over the poles and retained in position by means of wooden wedges driven in. At four points around the circular yoke, holes are drilled and tapped for ⅜-in. x 2¼-in. hexagon cap screws which serve to fasten the bearing shells to the field frame. In finishing the field frame it is bored out and the ends of the circular yoke faced off. The outer surface of the yoke also is trued up for a distance of 5-16 inch from each end, making the diameter of these finished portions 8⅛ inches, care being taken to have them true with the bore.

Fig. 13 shows an end view of the cover plate or bearing shell. It consists of a curved shell which covers the field coils and is bored for a short distance on its surface to fit over the turned portion of the steel field frame. In the center is a large circular opening of about the same diameter as the bore of the field and at the center of this opening is seen the case for containing the ball armature bearings. This is supported from the wall of the shell by means of four radial arms and these serve also to support the brush holders, for which purpose they are drilled for 7-16-in. holes.

A circular boss is located 5 inches out from the center of the armature bearings to take the 1½-in. axle upon which the motor is hinged. This dimension of 5 inches must be exact, for upon this depends the proper meshing of the gears. If preferred the boss may be bored somewhat larger than 1½ inches and an eccentric bushing inserted in the holes. This would give a means of adjustment for the gears. Fig. 14 is a side view of the bearing shown in Fig. 13. These are intended to be cast from an alloy of aluminum and zinc, known as alzinc, and consisting of two parts aluminum and one part zinc.

Fig. 15 is a vertical section of the complete motor, which shows, perhaps more clearly than any of the other views, all the working parts of the motor in their proper relation. This view brings out the bearing construction, the commutator, brush holders, and shows the driving pinion mounted on the ends of the armature shaft. The armature and field cores, it will be noted, are 2½ inches long axially and the yoke 4 inches, the pole-pieces being set ⅝ inch out of center with respect to the yoke, which allows the necessary space at one end of the machine for a commutator of ample size, and at the same time makes possible the use of cover plates which are exactly alike and therefore require only one pattern. The large central opening in the shell is bored and threaded to receive turned discs which, when screwed in, completely encase the motor. In this view such discs are shown in position. By removing the disc at the commutator end, the brushes and commutator may be inspected and the brushes renewed if necessary without disturbing any of the other parts.

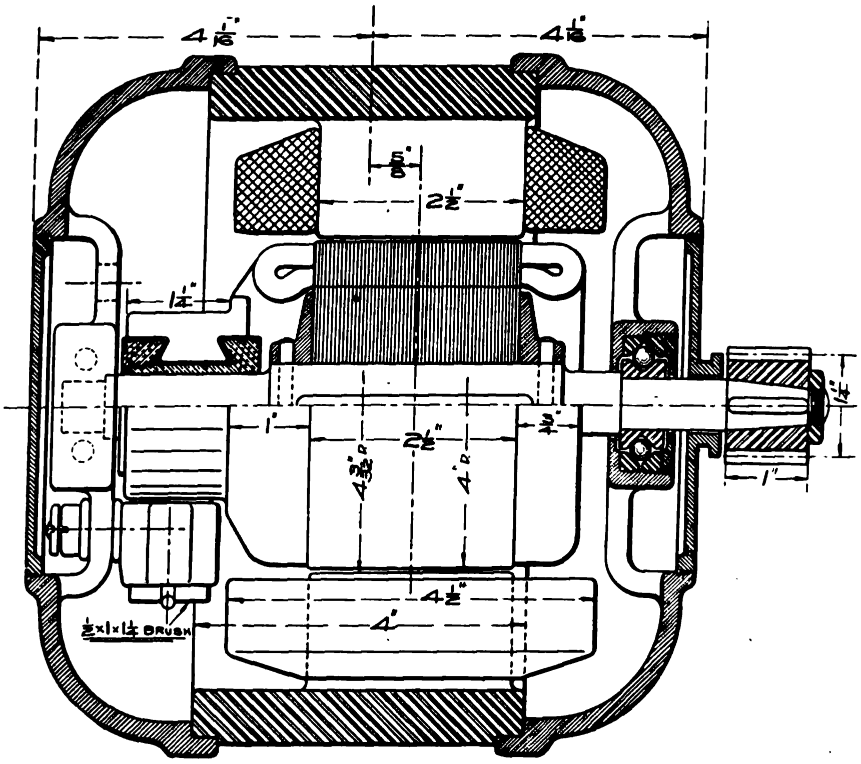


FIG. 15.—SECTION OF COMPLETE MOTOR.

The case for containing the ball armature bearings is to be bored and threaded to suit the steel races, the bore being, of course, exactly concentric with the finished portion at the back of the shell where it fits the field frame. The armature bearings are of the "grooved shaft ball bearing" type and are of a standard size which can be obtained ready made from any one of several manufacturers of ball bearings. They consist of three hardened tool-steel races and a set of twelve ¼-in. steel balls. One of these races is in the form of a spool which fits the shaft snugly, and of the other two, one is made a close fit for the case while the other is screwed into the case, which affords a means of adjusting the bearing. The driving pinion, which is shown at the right hand end of the motor shaft, is of machine steel of 1¼-in. pitch diameter, 1-in. face, and 12 pitch, with 15 teeth.

Fig. 16 is a detail of the armature shaft and end discs for the armature core. The shaft is to be turned from a piece of 1-in. cold rolled machine steel; the center portion will, therefore, not require turning if the piece has been accurately centered. A 3-16-in. key is provided on the shaft to match the key seat in the core discs, the discs being compressed between the two cast iron flanges; a 3-16-in. pin driven through both flanges and shaft secures them in position. The driving end of the armature shaft is turned taper and keyseated for the driving pinion; the length of the tapered portion should be 1 inch instead of 21-32 inch as called for in the drawing.

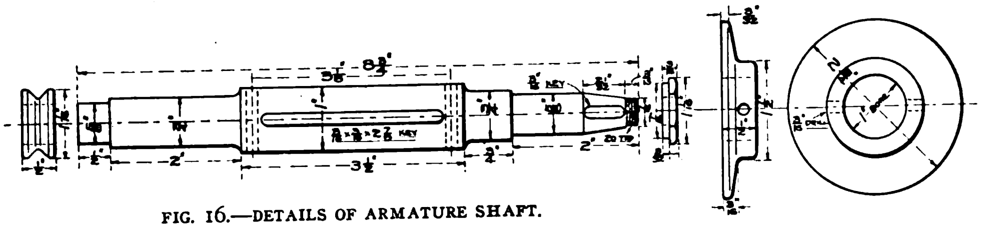


FIG. 16.—DETAILS OF ARMATURE SHAFT.

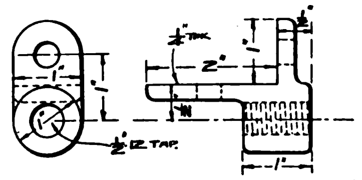


FIG. 20.—MOTOR HANGER ROD BRACKET.

Fig. 17 shows details of the commutator, brush holders, springs and insulation for same. The commutator can be most easily constructed from copper casting turned to the sizes shown and then sawed in 24 equal segments by means of a No. 23 screw-slotting cutter mounted on a mandrel in a lathe. The segments thus obtained are built up with mica insulation and are clamped in a brass sleeve and nut having flanges undercut at a 60-degree angle.

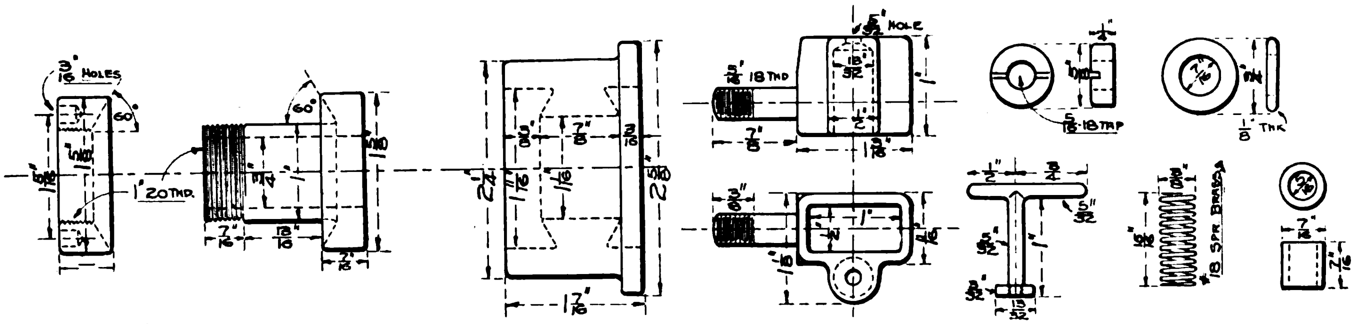


FIG. 17.—DETAILS OF COMMUTATOR, BRUSH-HOLDER, SPRINGS AND INSULATION FOR SAME.

The brush holders are of brass, and although of simple construction, some care is necessary in finishing them to secure the best results, particularly in filing out the slot, the sides of which should be parallel. The brush holders slide freely in the holder, but without lost motion. The brushes should be of plumbago ½ in. x 1 in. x 1¼ ins. and copper plated. A small flexible wire should be soldered to the top of each brush and fastened to the holder to secure a reliable connection between brush and holder.. The springs should be the lightest that can be used and still obtain a reliable contact between brushes and commutator; the spring shown will be about right. It can be made of "Helmet" bronze. The insulation for the brush holders consists of 8 washers of red fibre ¾ inch in diameter and ⅛ inch thick, with a 7-16-in. hole in the center; four small fibre bushings also are necessary.

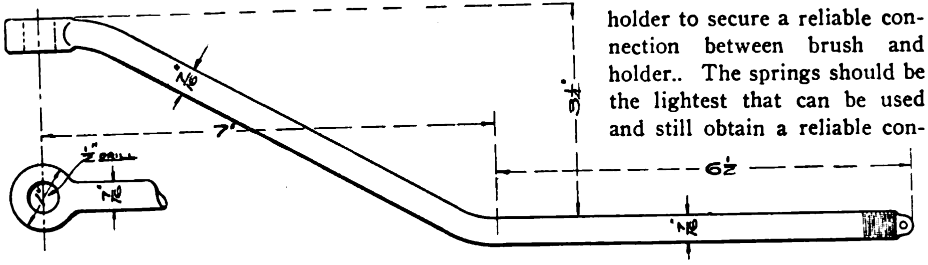


FIG. 19.—MOTOR HANGER ROD.

Fig. 18 shows the outlines and dimensions of the field and armature coils. These are to be form wound, taped and shellacked. Four field coils are required for each motor, each comprising 110 turns of No. 11 wire. And 24 armature coils are necessary, each containing 16 turns (4 wide and 4 deep) of No. 16 double cotton covered wire. The terminals of the armature coils are brought out as shown; they will then pass straight out to neighboring commutator segments. This makes a parallel lap winging with point of commutation at or near the center line of the pole pieces.

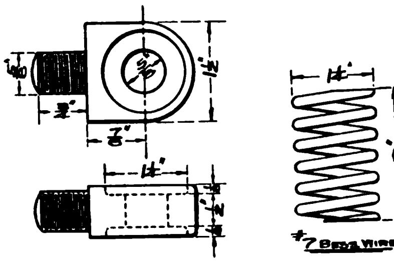


FIG. 21.—SPRING AND SUPPORTING EAR FOR MOTOR.

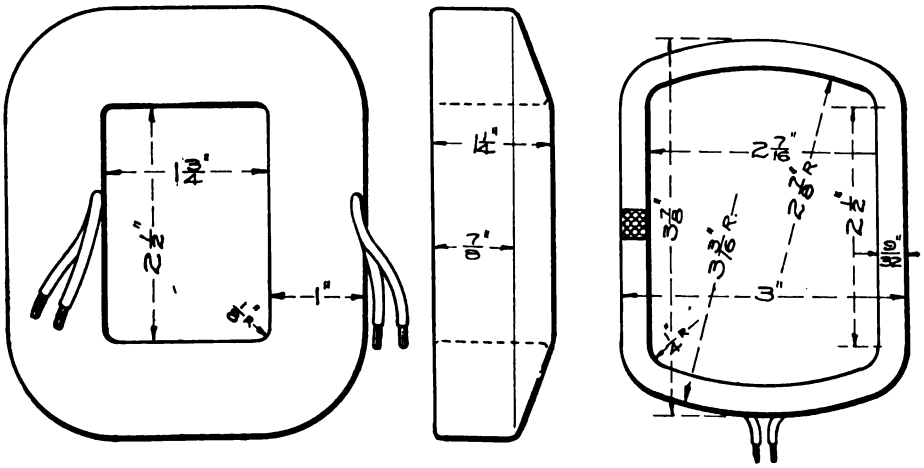


FIG. 18.—FIELD AND ARMATURE COILS.

Fig. 19 shows the motor hanger rod, used to suspend the motor from the frame; it is of 7-16-in. round iron with an eye at one end, and is bent outwardly 3¼ inches to conform with the arrangement of the motors, as shown in Fig. 2. Two such rods, just alike, are necessary.

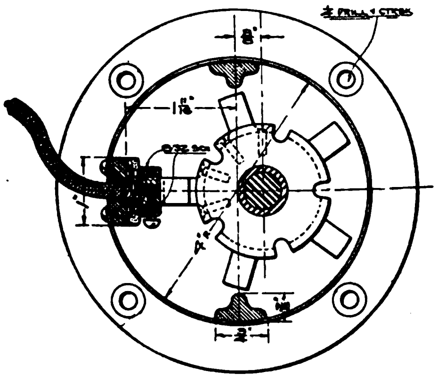
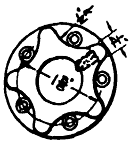
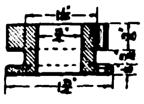


FIG. 23.—HORIZONTAL SECTION OF CONTROLLER.

Fig. 20 shows the bracket which is rivetel to the angle iron frame and is tapped ½ inch for supporting the motor hanger rod. This may be either a steel or an alzinc casting; two are required.

Fig. 21 shows the spring and supporting ear for the motor, two of which are necessary, one for each motor. This is turned and threaded ⅝ inch and screwed into a tapped hole in the motor frame. The springs are open coil springs of No. 7 bessemer wire. Four springs are necessary.





CONTROLLER.

Figs. 22 and 23 show respectively a vertical and a horizontal section of the controller. The frame of the controller is a casting; it may be iron or alzinc as preferred, and consists merely of a circular top and bottom which are joined by the upright ribs, the whole structure preferably in one piece. On one of the vertical ribs a piece of 3-16-in. fibre is fastened and upon this are mounted 14 stationary contacts of the knife switch pattern.

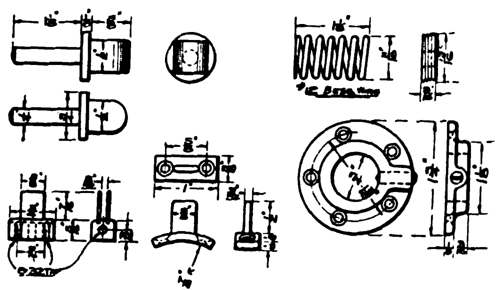


FIG. 24.—DETAILS OF CONTROLLER PARTS.

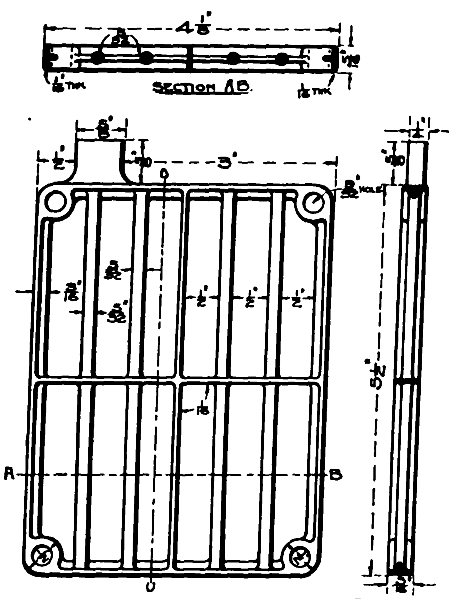


FIG. 26.—POSITIVE GRID.

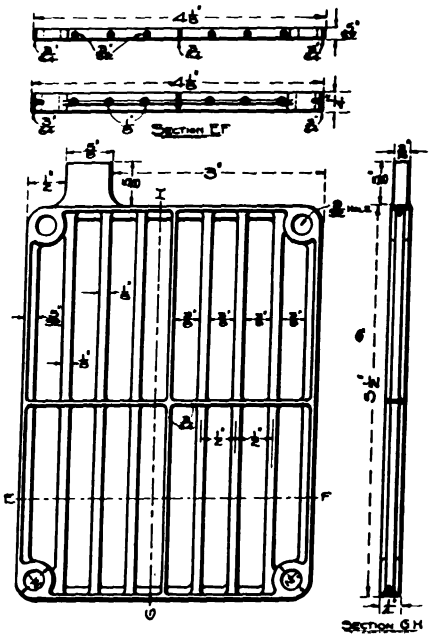


FIG. 27.—NEGATIVE GRID.

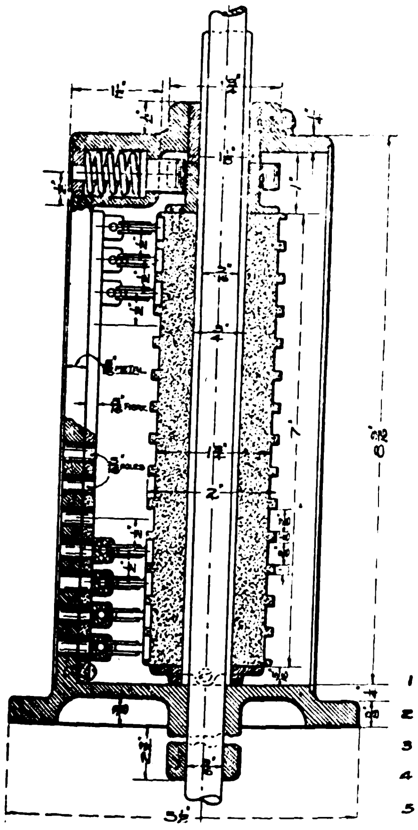


FIG. 22.—VERTICAL SECTION OF CONTROLLER.

The controller drum consists of a fibre cylinder 2 inches in diameter with a ¾-in. hole through the center, and has a series of 14 grooves turned in its periphery ⅜ inch wide and ⅛ inch deep. In these grooves are placed five rows of contact pieces, which, by engaging the stationary contacts, effect the various combinations desired. The controller drum is mounted on a piece of steel tubing ¾ inch outside diameter and about 9-16 inch inside diameter and is adapted to be turned by means of a small handle located just below the steering bar. It should be noted that the controller drum is out of center with the casing of controller by ⅜ inch, this being to allow for the space occupied at one side by the stationary contacts. A notched wheel and spring latch are provided as shown at the top of the controller to enable the operator to judge when he has brought the cylinder into the proper position. Fig. 24 shows some detail parts of the controller such as the stationary and moving contacts, spring, latch, and notched wheel. These will be readily understood without further explanation.

The wires from the battery and motors enter the controller from the back, one of the wires being shown in Fig. 23. These are to be of No. 10 rubber covered wire and are fastened into the stationary contact blocks by means of small set screws. Fig. 25 is a diagram of connections showing how the controller is wired and how it effects the various speed changes. The stationary contacts are numbered 1 to 14. On the first speed the motors are in series and the two 20-volt battery sections are in parallel; on the next speed the battery connections are in series and the motors also are still in series, and on the last speed the battery remains in series, while the motors are placed in multiple. On any of these speeds the double-pole single-throw switch may be closed, which as will be seen, places a resistance across each motor field, thus weakening the field and causing a corresponding increase in speed.

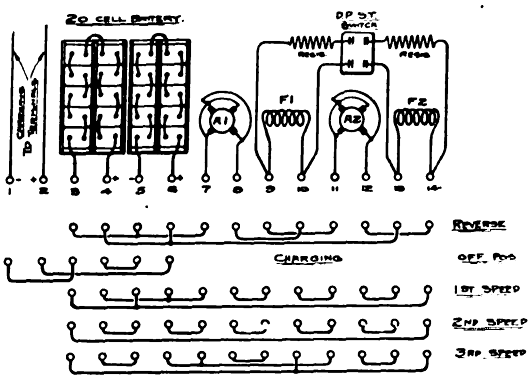


FIG. 25.—DIAGRAMS OF CONNECTIONS.

The value of the resistance can be determined only by experiment, care being taken not to exceed the safe discharge of the battery which is about 32 amperes.

The reverse speed, it will be noted, is the same as the first forward speed, except that the relations of fields and armatures are reversed. The "off" position of the controller is utilized as the charging position, and here the battery is in series and placed across the charging terminals.

THE BATTERY.

Almost any good make of storage battery may be used in the automobile which has been described. But for the benefit of those who wish to construct their own battery, a high capacity type of cell is shown which can be used in the runabout with good re-

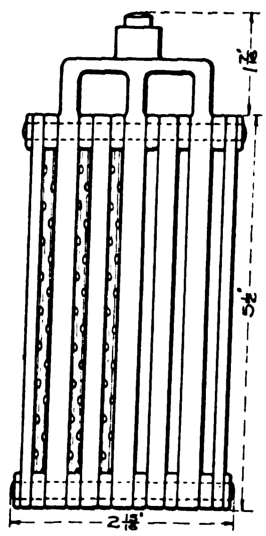


FIG. 28.—COMPLETE ELEMENT.

sults, both as to capacity and durability. The battery has pasted plates consisting of lead peroxide for the positives and metallic lead for the negatives in an electrolyte of dilute sulphuric acid. The paste is applied to metallic grids cast from an alloy of lead and antimony containing 10 per cent to 12 per cent of antimony. The requirements for a positive and a negative grid being somewhat different, a different grid is used for each.

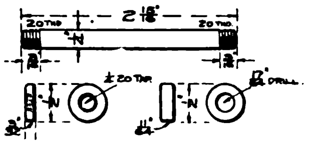


FIG. 29.—ROD, NUTS AND WASHERS.

Fig. 26 shows the positive grid. This consists of a light rectangular frame having sides of T-shaped section and provided at the four corners with circular bosses having holes for the binding rods to pass through. The frame serves merely as a gauge to give definite form and thickness to the mass of active material contained in it. And for conducting the current to and from the active material, a series of round conducting rods is provided extending in a vertical direction and terminating in the frame and ribs. These conductors are made 5-32 inch in diameter in the case of the positive grid. A lug is provided at the top of the grid for the purpose of making electrical connection with the finished plates.

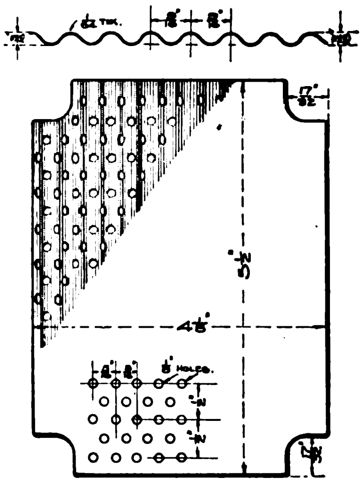


FIG. 30.—INSULATING SHEET.

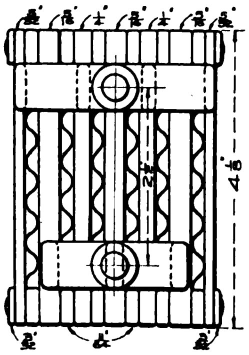


FIG. 31.—PLAN VIEW OF AN ELEMENT.

The material which is applied to the positive grid and which later, during the process of formation, becomes the active material, consists of minium or red lead with a slight admixture of litharge. This mixture of oxide is moistened with a solution of ammonium sulphate and while it is in a plastic condition the grid is filled until the material stands flush or a trifle above the edge of the rectangular frame. The grid and its contents are then subjected to pressure between some layers of absorbent material, such as blotting paper, under a screw press or other convenient means to remove excess moisture and to further compress the material.

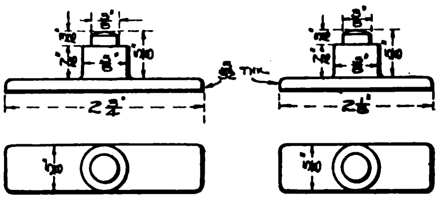


FIG. 32.—TERMINALS.

Fig. 27 shows the negative grid. This is similar to the positive, except that it is made lighter throughout and also of less depth by about 20 per cent. The two end negatives, of which a section also appears in Fig. 27, are to be only about one-half the thickness of the other negatives for the reason, of course, that as they are active on one face only they will require only one-half the amount of active material required by the other plates which are active on both faces. The end negatives are 5-32 thick, the middle negatives being ¼ inch. All negative grids are to be cast of antimonious lead as in the case of the positives. The material used for filling the negative grids consists of litharge with a slight admixture of minium. In this case the mixture should be moistened with a very dilute solution of sulphuric acid. The grid is filled and compressed in much the same manner as the positive.

After plates have been prepared as described, a sufficient number to constitute a complete element are assembled in the form shown in Fig. 28, where there are seven plates composing an element, three of which are positive and the remaining four negative. The plates are separated from each other and bound together by means of some hard rubber screw rods and washers which are shown in detail in Fig. 29. Hard rubber rod, or any non-conducting composition of similar nature, may be used for making these rods. In addition to the rods and washers, some perforated and corrugated separators are placed between the finished plates as an extra precaution against short-circuiting of the elements. Fig. 30 shows such a separator, made of hard rubber sheet 1-64 inch thick, but grooved cherry wood separators are also sometimes used for this purpose. Fig. 31 shows a plan view of the complete element with separators in position.

When the plates have been properly assembled it is necessary to connect plates of the same polarity in multiple with each other, and for this purpose some strap connectors are to be provided. These are shown in Fig. 32. They are of different lengths, the short one being for the positives and the long one for the negatives. These terminal pieces are to be cast of lead antimony as are the grids, and are soldered or burned to the lugs at the top of the plates, in doing which a fillet of metal should be left in the angles to strengthen and protect the joints. To further protect the terminals and their connections from undue action by the electrolyte, it is advisable to coat these parts with acid proof paint. When all elements are thus completed they are placed in jars, connected in series and formed by the passage of a continuous current in one direction through the cell until all the material on the positive has been converted to peroxide and all that on the negative has been reduced to metallic lead. During the process of formation it is preferable to use a very dilute solution of sulphuric acid, much lower in strength than the regular electrolyte, in order to avoid as far as possible the sulphating of the material, which if it is allowed to occur delays the formation.

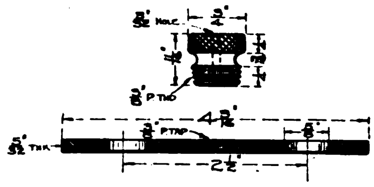


FIG. 33.—COVER AND PLUG.

When formation is complete, and this is best indicated by the color of the plates, which should be uniform throughout (dark brown for the positives and gray for negatives), the forming solution may be turned out and replaced by the regular electrolyte of 1.275 to 1.300 specific gravity, which should, of course, be cold before it is placed in cells.

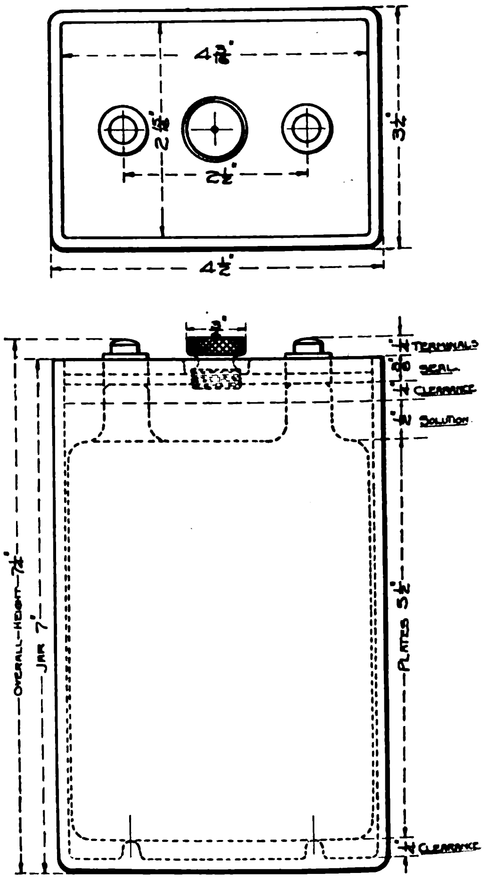


FIG. 34.—COMPLETE CELL.

The next step after the cells have been

properly formed is to seal the top of each jar, thus rendering it water tight and preventing the loss of electrolyte through evaporation or spilling. For this purpose some covers and plugs are to be provided as shown in Fig. 33. The cover is simply a piece of hard rubber sheet ⅛ inch to 5-32 inch thick of such size that it fits snugly into the top of the jar and drilled with holes for the terminals and vent plug. The compound to be used for sealing is best obtained in prepared form from some battery manufacturer. It usually requires to be heated, and while in liquid state, is poured into the space at the top of the jar. Fig. 34 shows a plan and elevation of the complete cell sealed in hard rubber jar. This view indicates the space occupied by the various parts, the overall dimensions of the hard rubber jar being 3¼ in. x 4½ in. x 7 ins.; the weight of a complete cell is 9½ pounds.

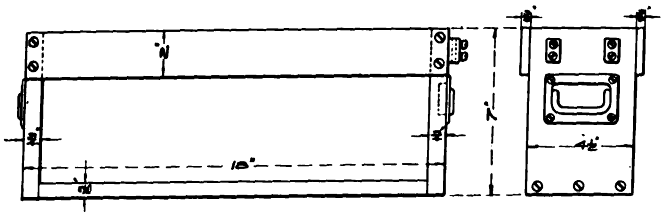


FIG. 35.—HARD WOOD BATTERY TRAY.

Fig. 35 shows two views of a hard wood tray for containing five cells of the size above mentioned. Four such trays are required for the runabout. They should be made of some substantial hard wood, such as cherry or ash, and thoroughly coated with P. & B. or acid proof paint.

Fig. 36 illustrates some curves of discharge of the battery just described. The 22-ampere rate is somewhat higher than the normal discharge rate required on the runabout, but even this shows a capacity of 55 ampere-hours or sufficient for a run of about 35 miles. The 32-ampere discharge is about the highest safe continuous rate, and will give a speed of 18 to 20 miles an hour. The cells should not be discharged below 1.75 volts per cell or 35 volts for the battery. And each cell should be gone over occasionally with low reading voltmeter and hydrometer to ascertain their individual condition. One or two poor cells in a battery will make a noticeable change in the running of the machine. In charging the cells the current should be kept until the e. m. f. reaches 50 volts for the battery at a low rate of 2 to 5 amperes.

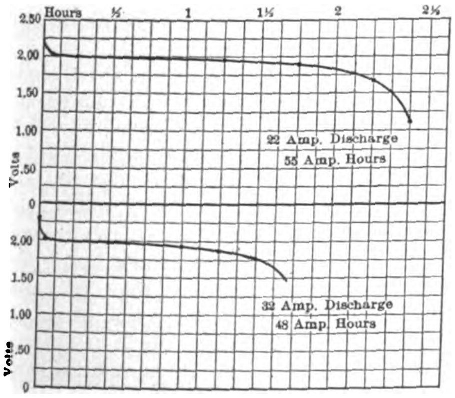


FIG. 36.—DISCHARGE CURVES.

HEATING AND VENTILATING BY FORCED BLAST.

BY CHAS. L. HUBBARD.

The term "fan" is commonly applied to any form of apparatus for moving air in which revolving blades of the propeller type are used, while the word "blower" is applied to fans which are enclosed in casings or "housings." Fans of this type are called centrifugal fans because the air is moved by centrifugal force, that is, it is thrown off from the tips of the revolving blades in the same way, to use a homely illustration, that water and mud are thrown from the revolving rim of a carriage wheel. As the air is thrown from the blades it produces a certain pressure within the fan casing, which causes it to flow from the discharge opening and through the connecting ducts. In the mean time, air from the outside flows in through the inlet openings near the center of the fan to take the place of that which is passing out through the outlet or discharge.

When the fan casing has an inlet opening in one side only, it is commonly called an exhauster. If there are inlets upon both sides, it is called a blower. In practice, exhausters are often used as blowers, and are always thus used when connected with an encased heater. The discharge opening can be arranged in any position desired, either up or down, horizontal, or at any angle. Where the height of the fan room is limited, a form called a three-quarter housing may be used, in which the lower part of the casing is replaced by a brick pit below the floor level.

The volume of air which a given fan will deliver depends upon the speed at which it is run and the friction and resistance through the heater and air-ways. The pressure referred to in connection with a fan is that in the discharge outlet of the casing, and represents the force which drives the air through the ducts and flues. The greater the pressure with a given resistance in the ducts, the greater will be the volume of air delivered, of course, and the greater the resistance, the greater will be the pressure required to deliver a given quantity of air. Fan wheels of the same manufacture are usually made with a constant ratio between the diameter and width, although special forms are made in which this does not hold true.

Most practical data on the action of fans is based on the results of tests, and from these the following relations have been found to be approximately correct. (1) The volume of air delivered varies directly as the speed; that is, doubling the number of revolutions doubles the volume of air delivered. (2) The pressure varies as the square of the speed; for example, if the speed is doubled, the pressure is increased $2 \times 2 = 4$ times. (3) The power required to drive the fan varies as the cube of the speed; thus, if the speed is doubled, the power required is increased $2 \times 2 \times 2 = 8$ times.

Suppose in a given case it were desired to double the volume of air delivered by a fan. At first thought, it might seem that the result could be easily obtained by merely doubling the speed, but upon considering the power required, it becomes evident that this will have to be increased eight-fold, and it will probably be much cheaper in the long run to put in a larger fan and run it at a lower speed.

It has been found by experiment that a centrifugal fan enclosed in a case has the ability, when run at a certain speed, to maintain a pressure corresponding to the velocity of the fan tips, over an area which is called the "capacity area" or the "square inches of blast." If this area be increased, the pressure will drop, but if it be reduced in size, even to the point of closing it entirely, the pressure will remain practically the same. The capacity area of a fan under ordinary conditions is given approximately by the equation: $d\,w \div 3 = a$, in which a is the diameter of the fan wheel in inches, and w is the width of the blades at the tip. The pressures corresponding to different peripheral velocities have been determined by experiment, so that by assuming a given speed for any fan the pressure may be found, and knowing the pressure and the square inches of blast (capacity area) over which this pressure acts, the delivery of the fan can be determined theoretically, assuming the fan to discharge into the open air.

It has been found in practice that fans of the blower type, having curved blades, operate quietly and give good results when running at a speed of about 3,600 feet per minute at the circumference of the wheel. This gives a pressure of about ½ ounce per square inch at the discharge outlet, which corresponds to that required for ordinary ventilating work, such as school buildings, halls, churches, etc. Higher speeds entail a greater expenditure of power, and are likely to produce a roaring noise and to cause vibration; on the other hand, a lower speed does not provide sufficient pressure to give proper control of the air distribution during strong winds.

TABLE I.—FAN SIZES AND CAPACITIES.

Diameter of fan wheel, in inches.	Height of housing in inches.	Approximate axial width of housing.	Speed giving ½ ounce pressure.	Cubic feet of air delivered per minute.	Horse-power of engine to drive fan.
18	30	9	870	1000	½
24	40	12	580	1600	1
30	50	15	465	2600	1
36	60	18	390	4500	2
42	70	21	333	6000	2½
48	80	24	293	8000	2½
54	90	28	260	11000	4
60	100	32	233	12500	4
72	120	43	195	21500	7
84	140	48	167	28600	9
96	160	48	147	31800	10
108	...	54	130	40400	13
120	...	60	117	51000	16

Table I gives the average capacities of different sizes of fans running at such speeds as to give ½ ounce of pressure, and the corresponding horse-power required. If an electric motor is used, the horse-power should be increased from 20 to 30 per cent to meet any emergency or unlooked-for conditions which may arise. In the case of an engine, the steam pressure or cut-off may be increased to meet any special requirements, but continuous overloading of a motor is apt to cause sparking and heating.

The air quantities given in the table are for cases where the fan has a single inlet and is used with a deep pipe heater. When the fan is placed in a room so that double inlets can be used and the air drawn through a comparatively shallow heater and delivered to ducts of generous size, the quantity of air moved will be somewhat larger. The following rule may be used in cases of this kind for fans with casings of standard proportions:

The peripheral velocity of the wheel divided by 1.6 and multiplied by the area of the outlet, gives approximately the cubic feet of air discharged per minute.

In a system of forced circulation by means of a fan, the action is positive and practically constant under all usual conditions of outside temperature and wind action. This gives it a decided advantage over natural or gravity methods, which are affected to a greater or less degree by changes in wind pressure, and renders it especially well adapted to the ventilation and warming of large buildings such as halls, shops, etc., where large and definite air quantities are required.

There are two distinct methods of ventilation in use, known as the exhaust and plenum methods. The exhaust method consists in drawing the air out of a building and providing for the heat thus carried away by placing steam coils under windows or in other positions where the inward leakage is supposed to be the greatest. When this method is used a partial vacuum is created within the building or room, and all currents and leaks are inward; there is nothing to govern definitely the quality and place of introduction of the air, and it is difficult to provide suitable means for warming it. In the plenum method the air is forced into the building, and its quality, temperature and point of admission are completely under control. All spaces are filled with air under a slight pressure and the leakage is outward, thus preventing the drawing of foul air into the room from any outside source. But above all, ample opportunity is given for properly warming the air by means of heaters, either in direct connection with the fan or in separate passages leading to the various rooms.

A simple, quiet running engine is desirable for use in connection with a fan. It may be either horizontal or vertical, and for school-houses, churches, etc., should be provided with a large cylinder so that the required power may be developed without carrying a boiler pressure above 25 or 30 pounds. In some cases cylinders are used of such size that a pressure of 10 or 15 pounds is sufficient. The quantity of steam which the engine consumes is of minor importance, as the exhaust can be turned into the coils and used for heating purposes. If space allows, the engine should preferably be belted to the fan. When it is direct-connected there is liable to be trouble from noise, as any slight looseness or pounding in the engine will be communicated to the air ducts and the sound will be carried to the rooms above. Electric motors are particularly well adapted for use in connection with fans; they are easily controlled by a switch and starting box or regulator, and the motor may be direct-connected to the fan shaft or belted.

The heaters used in connection with the different makes of fans are similar in construction, consisting of sectional cast-iron bases with vertical loops of wrought-iron pipe connected across the top. The steam enters the upper part of the base or header and passes up one side of the loop, then across the top and down on the other side where the condensation is taken off through the return drip, which is separated from the inlet by a partition. The heaters are commonly made in sections of two and four rows of pipes each. The height varies from 3 1-3 feet to 9 feet and the width from 3 to 7 feet in the standard sizes. They are usually made up of 1-in. pipe, although 1¼-in. is often used for the larger sizes. The efficiency of the heaters used in connection with forced blast varies greatly, depending upon the temperature of the entering air, its velocity between the pipes, the temperature to which it is raised, and the steam pressure carried in the heater. The general manner in which the heater is made up is also an important factor.

In designing a heater of this kind, care must be taken that the free area between the pipes is not concentrated to such an extent that an excessive velocity will be required to pass the given quantity of air through it. In ordinary work it is customary to assume a velocity of 800 to 1,000 feet per minute; higher velocities call for a greater pressure on the fan, which is not desirable in ventilating work. In the heater described, about 40 per cent of the total area is free for the passage of air; for example, a heater 5 feet wide by 6 feet high would have a total area of 30 square feet, and a free area between the pipes of $30 \times 0.4 = 12$ square feet. The depth or number of rows of pipe does not affect the free area, although the friction is increased and additional work is thrown upon the fan. The efficiency of any given heater will be increased by increasing the velocity of the air through it, but the final temperature will be diminished; that is, a larger quantity of air will be heated to a lower temperature in the second case, and while the total heat given off is greater, the air quantity increases more rapidly than the heat quantity, which causes a drop in temperature.

Increasing the number of rows of pipe in a heater increases the final temperature of the air, but diminishes the efficiency of the heater because the average difference in temperature between the air and steam is less. Increasing the steam pressure in the heater, and consequently its temperature, will increase both the final temperature of the air and the efficiency of the heater. Table II has been prepared from different sources and may be used as a guide in computing the probable results under ordinary working conditions. In this table it is assumed that the air enters the heater at a temperature of 10 degrees below zero and passes between the pipes with a velocity of 800 feet per minute. The right-hand section of the table gives the efficiencies of the heater corresponding to the data in the left-hand section. For example, air passing through a heater 10 pipes deep and carrying 20 pounds pressure will be raised to a temperature of 90 degrees and the heater will give off 1,650 heat units per square foot of surface per hour. When air is taken in at zero 10 degrees may be added to the final temperatures given in the table, although theoretically it would be slightly less; in this case we must take the efficiency corresponding to the final temperature after the 10 degrees have been added. For a velocity of 1,000 feet, multiply the temperature given in the table by 0.95 and the efficiencies by 1.13.

TABLE II.—AVERAGE HEATER PERFORMANCE.

Rows of pipe deep.	Temperature to which air will be raised from 10 degrees below zero, with steam pressures in heater of			Efficiency of the heating surface in heat units per square foot per hour, with steam pressures in heater of		
	5 lbs.	20 lbs.	60 lbs.	5 lbs.	20 lbs.	60 lbs.
4	30	35	45	1600	1800	2000
6	50	55	65	1600	1800	2000
8	65	70	85	1500	1650	1850
10	80	90	105	1500	1650	1850
12	95	105	125	1500	1650	1850
14	105	120	140	1400	1500	1700
16	120	130	150	1400	1500	1700
18	130	140	160	1300	1400	1600
20	140	150	170	1300	1400	1600

The method of computing the size of a heater and the use of the table may best be illustrated by an example. How many square feet of radiation will be required to raise 600,000 cubic feet of air per hour from 10 below zero to 80 degrees, with a velocity through the heater of 800 feet per minute, and a steam pressure of 5 pounds? What must be the total area of the heater front and how many rows of pipe must it have?

$600{,}000 \times (80 + 10) \div 55 = 981{,}818$ heat units required.

The table shows that for the above conditions, a heater 10 pipes deep is required, and that an efficiency of 1,500 heat units will be obtained. Then the surface required will be $981{,}818 \div 1{,}500 = 654$ square feet; the volume of air, $600{,}000 \div 60 = 10{,}000$ cubic feet per minute, and the free area through the heater, $10{,}000 \div 800 = 12\frac{1}{2}$ square feet. Assuming 40 per cent of the total heater front to be free for the passage of air, the total area will be $12.5 \div 0.4 = 31\frac{1}{4}$ square feet; 31, of course, would be sufficiently accurate.

For convenience in estimating the approximate dimensions of a heater, Table III is given. The standard heaters made by different manufacturers vary somewhat, but the dimensions given in the table represent average practice. Column 3 gives the square feet of heating surface in a single row of pipes of the dimensions given in columns 1 and 2, and column 4 gives the free area between the pipes. In calculating the total height of the heater, one foot should be added for the base. These sections are made up of 1-in. pipe, except the last or 7-ft. sections, which are made of 1¼-in. pipe.

Using this table in connection with the example just given, the reader should look in the last column for a section having a free area of 12½ feet; here it is shown that a 5-ft. x 6½-ft. section has a free opening of 13 square feet and a radiating surface of 62 square feet. The conditions call for 10 rows of pipe, and 10 × 62 = 620 square feet of radiating surface, which is slightly less than called for but which would be near enough for all practical purposes.

Where forced blast is used for the warming of shops and factories, the proportional heating surface is usually expressed in the number of cubic feet in the building for each linear foot of 1-in. steam pipe in the heater. On this basis, in factory practice with all of the air taken from out of doors, it is customary to allow from 100 to 150 cubic feet of space per foot of pipe, according as exhaust or live steam is used; live steam in this case being steam at about 80 pounds pressure. If practically all of the air is returned from the building to the heater, these figures may be raised to about 140 as a minimum, and possibly 200 as a maximum, per foot of pipe.

TABLE III.—HEATER DIMENSIONS.

Width of section.	Height of pipes.	Square feet of surface.	Free area through heater in square feet.
3 ft.	3 ft. 6 in.	20	4.2
	4 ft. 0 in.	22	4.8
	4 ft. 6 in.	25	5.4
	5 ft. 0 in.	28	6.0
4 ft.	4 ft. 6 in.	34	7.2
	5 ft. 0 in.	38	8.0
	5 ft. 6 in.	42	8.8
	6 ft. 0 in.	45	9.6
5 ft.	5 ft. 6 in.	52	11.0
	6 ft. 0 in.	57	12.0
	6 ft. 6 in.	62	13.0
	7 ft. 0 in.	67	14.0
6 ft.	6 ft. 6 in.	75	15.6
	7 ft. 0 in.	81	16.8
	7 ft. 6 in.	87	18.0
	8 ft. 0 in.	92	19.2
7 ft	7 ft. 6 in.	98	21.0
	8 ft. 0 in.	108	22.4
	8 ft. 6 in.	109	23.8
	9 ft. 0 in.	116	25.2

The heaters in the above table may be changed to linear feet of 1-in. pipe by multiplying the numbers in column 3 (square feet of surface) by 3.

With the blower type of fan the size of the main ducts may be based on a velocity of 1,200 to 1,500 feet per minute, the branches on a velocity of 1,000 to 1,200 feet per minute, and as low as 600 to 800 feet when the pipes are small. Flue velocities of 500 to 700 feet may be used, although the lower velocity is preferable in the case of large buildings. The size of the inlet register should be such that the velocity of the entering air will not exceed about 300 feet per minute. The velocity between the inlet windows and the fan or heater may be from 800 to 1,000 feet.

The varying exposures of the rooms of a building require that more heat shall be supplied to some than to others. Rooms that are on the south side of the building and exposed to the sun may perhaps be kept perfectly comfortable with a supply of heat that will maintain a temperature of only 50 or 60 degrees in rooms on the opposite side of the building which are exposed to high winds and shut off from the warmth of the sun.

With a constant and equal air supply to each room, it is evident that the temperature must be directly proportional to the cooling surfaces and exposure, and that no building of this character can be properly heated and ventilated if the temperature cannot be varied without affecting the air supply. There are three ways of overcoming this difficulty. The older arrangement consists in heating the air by means of a primary coil, at or near the fan, to about 60 degrees, or to the minimum temperature required within the building. From the coil it passes to the bases of the various flues and is there still further heated as required by secondary heaters placed at the base of each flue.

With the second, and more recent method, a single heater is employed and all of the air is heated to the maximum required to maintain the desired temperature in the most exposed rooms, while the temperature of the other rooms is regulated by mixing with the hot air a sufficient volume of cold air at the bases of the different flues. This result is best accomplished by designing a hot blast apparatus so that the air shall be forced rather than drawn through the heater, and by providing a by-pass through which it may be discharged without passing across the heated pipes. The passage for the cold air is usually made above and separate from the heater pipes. Extending from the apparatus is a double system of ducts, usually of galvanized iron. At the base of each flue is placed a mixing damper which is controlled by a chain from the room above and arranged so as to admit either a full volume of hot air, a full volume of cold air, or to mix them in any desired proportion without affecting the resulting total volume delivered to the room.

The third method consists in delivering the air to all of the rooms at a temperature of 68 per cent or 70 per cent for ventilating purposes only, and supplying the necessary heat for warming by means of direct radiation placed in the rooms.

* * *

DIRECT CURRENT MOTOR WIRING.

BY P. C. PERCY.

In cases where a motor user has only one machine, the wiring is of the simplest possible character, consisting merely of two continuous wires running side by side from the entrance to the motor, as shown by Fig. 1. For open (surface) work, the wires may be insulated with "slow-burning weatherproof" covering or with rubber and braid. They must be carried on porcelain knobs or cleats, not less than ½ inch from the wall or ceiling surface and 2½ inches from each other, if the voltage does not exceed 300; if it does, these distances must be increased to 1 inch and 4 inches respectively. The cleats or knobs must be located at intervals not greater than 4½ feet, except in the case of No. 8 or larger wires strung in unceiled buildings; these may be supported only at each joist, girder, or other timber, even though these may be located at greater intervals than 4½ feet. For all other classes of work, only rubber-covered wire is allowed. In conduit work it is preferable to run a single line of conduit and put both wires in the one tube; twin or duplex wires may be used, and this arrangement is much preferable mechanically. Moulding may be used only in open, dry places, and for potentials not exceeding 300 volts.

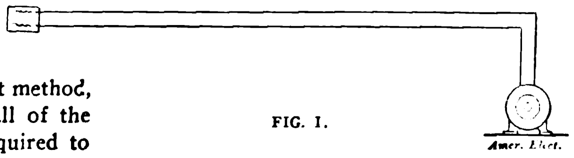


FIG. 1.

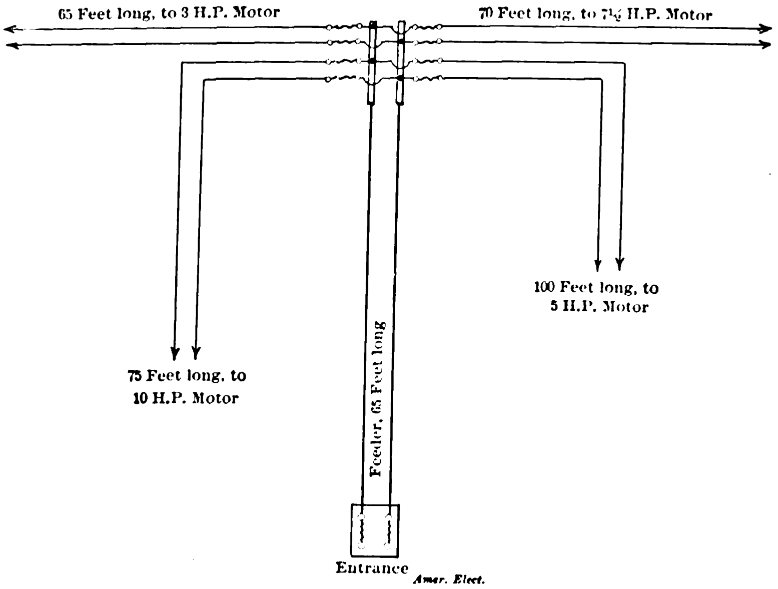

65 Feet long, to 3 H.P. Motor
70 Feet long, to 7½ H.P. Motor
75 Feet long, to 10 H.P. Motor
100 Feet long, to 5 H.P. Motor
Feeder, 65 Feet long
Entrance
Amer. Elect.

FIG. 2.

The size of wire to be used for such an installation is readily determined by means of Table I or II, according to the voltage. Table I will serve with sufficient accuracy for 115-volt and 230-volt circuits, as well as those on which it is based. Tables III, IV and V will also be found convenient. Table III shows the current required by motors of various commercial efficiencies; Table IV shows the current taken by motors of the efficiencies commonly found in practice, and Table V shows at a glance the smallest wire that may be used for a motor of given output without violating the Underwriters' Code; it is based on the figures given in Table IV. Table III will be found useful for laying out wiring for motors of known efficiency before the motors have been actually received; when the efficiency is not positively known, Table IV may be used. All of the tables are calculated for the full-load currents of course; this is the only allowable basis, even though a motor may not be given its full load once a week.

TABLE I.—110-VOLT AND 220-VOLT DIRECT-CURRENT MOTORS.

The numbers in the body of the table are the Amperes that the different sizes of wire will carry to the Distances given in the left-hand section of the table, with the percentages of Drop stated at the heads of the distance columns.

Drop: 110 volts: 2%	3%	4%	5%	6%	Wire Numbers; B. & S. Gauge:											
220 volt: 1%	1½%	2%	2½%	3%												
Distance; Feet					00	0	1	2	3	4	5	6	8	10	12	14
26	39	52	65	78	...	...	...	...	...	..	..	..	..	..	..	16.4
28	42	56	70	84	...	...	...	...	...	..	..	..	..	..	..	15.3
30	45	60	75	90	...	...	...	...	...	..	..	..	..	..	22	14.2
32	48	64	80	96	...	...	...	...	...	..	..	..	..	..	21	13.3
34	51	68	85	102	...	...	...	...	...	..	..	..	..	32	20.1	12.6
36	54	72	90	108	...	...	...	...	...	..	..	..	..	30	19	11.9
38	57	76	95	114	...	...	...	...	...	..	..	..	45	28	18	11.2
40	60	80	100	120	...	...	...	...	...	..	..	..	42	27	17.1	10.7
42	63	84	105	126	...	...	...	...	...	..	..	65	41	25	16.3	10.2
44	66	88	110	132	...	...	...	...	...	..	..	62	39	24	15.5	9.7
46	69	92	115	138	...	...	...	...	...	..	75	60	37	23	14.9	9.3
48	72	96	120	144	...	...	...	...	...	..	72	57	35	22	14.2	8.9
50	75	100	125	150	...	...	...	...	110	87	79	55	34	21	13.7	8.5
52	78	104	130	156	...	...	...	...	105	83	66	53	33	20	13.1	8.2
54	81	108	135	162	...	...	...	129	102	80	64	51	31	20	12.7	7.9
56	84	112	140	168	...	...	156	124	98	77	62	49	30	19.3	12.2	7.6
58	87	116	145	174	...	...	151	120	94	75	59	47	29	18.6	11.8	7.4
60	90	120	150	180	...	183	146	116	91	72	57	45	28	18	11.4	7.1
63	94	126	157	189	219	174	139	110	87	69	55	43	27	17	10.8	6.8
66	99	132	165	198	209	166	132	105	83	66	52	41	26	16.3	10.3	6.5
72	108	144	180	216	191	152	121	96	76	60	48	38	23	15	9.5	5.9
78	117	156	195	234	177	141	112	89	70	55	44	35	22	13.8	8.8	5.5
84	126	168	210	252	164	131	104	82	65	51	41	32	20	12.8	8.1	5.1
90	135	180	225	270	153	122	97	77	61	48	38	30	19	12	7.6	4.7
96	144	192	240	288	143	114	91	72	57	45	36	28	17	11.2	7.1	4.4
102	153	204	255	306	135	108	85	68	54	42	34	27	16	10.6	6.7	4.2
108	162	216	270	324	127	102	81	64	51	40	32	25	15	10	6.3	3.9
114	171	228	285	342	121	96	76	61	48	38	30	24	15	9.4	6	3.7
120	180	240	300	360	115	91	73	58	45	36	28	23	14	9	5.7	3.5
130	195	260	325	390	106	84	67	53	42	33	26	21	13	8.3	5.2	3.3
140	210	280	350	420	98	78	62	49	39	31	24	19.6	12.2	7.7	4.9	3
150	225	300	375	450	92	73	58	46	36	29	23	18.3	11.4	7.2	4.5	2.8
160	240	320	400	480	86	68	54	43	34	27	21.6	17.2	10.7	6.7	4.3	2.6
170	255	340	425	510	81	64	51	41	32	25	20.3	16.2	10	6.3	4	2.5
180	270	360	450	540	76	61	48	38	30	24	19.2	15.2	9.5	6	3.8	2.3
190	285	380	475	570	72	58	46	36	29	22.9	18.2	14.4	9	5.7	3.6	2.2
200	300	400	500	600	69	55	43	35	27	21.8	17.3	13.7	8.5	5.4	3.4	2.1
210	315	420	525	630	65	52	41	33	26	20.7	16.4	13	8	5.1	3.2	2
220	330	440	550	660	62	50	39	31	25	19.7	15.7	12.5	7.8	4.9	3.1	1.9
230	345	460	575	690	60	47	38	30	24	18.9	15	11.9	7.4	4.7	3	1.8
240	360	480	600	720	57	45	36	29	23	18.2	14.4	11.4	7.1	4.5	2.8	1.7
250	375	500	625	750	55	44	35	27	22	17.4	13.8	11	6.8	4.3	2.7	1.7

When an installation comprises several motors, a feeder should be run to a distributing point located as nearly equidistant, electrically, from the motors as possible, and a panel board installed there, from which should radiate individual sub-feeders, one for each motor, as indicated in Fig. 2. The main feeder wire should be of such size that the drop in it will be smaller than the drop in any one of the individual sub-feeders, so that the variations in the loads of some machines will affect the speeds of others as little as practical conditions will permit. For example, suppose four 220-volt motors are to be installed, of the sizes and at the distances indicated in Fig. 2, and the maximum drop at any motor must be within 3 per cent. For simplicity, it is advisable to divide up the drop in whole numbers; thus, the feeder might be given 1 per cent. of the drop and each sub-feeder the remainder, not to exceed 2 per cent.

Supposing the motors to be of ordinary efficiencies, the current carried by the feeder will be practically 100 amperes at full load. Table I shows that No. 2 wire will carry 105 amperes 66 feet with a drop of 1 per cent. (at 220 volts), so this would be the size of wire to use for the feeder. The 3-h.p. sub-feeder must carry 13 amperes 65 feet with a drop not exceeding 2 per cent.; the table (I) shows that No. 14 wire will just do this comfortably. The table also indicates that the 5-h.p. sub-feeder, to carry 20 amperes 100 feet, must be of No. 10 wire; the 7½-h.p. sub-feeder (29 amperes, 70 feet), of the same size, and the 10-h.p. sub-feeder (39 amperes, 75 feet), of No. 8, although that wire is a trifle larger than the drop necessitates. No. 10 wire is limited to 32 amperes, so that it could not be used, even if the distance were only 10 feet instead of 75. Too much stress cannot be laid upon the advisability of consulting the figures of Table V at each step of the process of determining wire sizes, so that sizes may not be chosen that will have to be changed afterwards. The reader should also make it a rule to allow a slight margin in all cases, in either the distance or the current to be carried; thus, if a measured distance is 38 feet, take the nearest *higher* number in the wiring table, or if a wire is to carry theoretically 113 amperes, take the next highest number of amperes in the wiring table.

TABLE II.—500-VOLT DIRECT-CURRENT MOTORS.

The numbers in the body of the table are the Amperes that the different sizes of wire will carry to the Distances given in the left-hand section of the table, with the percentages of Drop stated at the heads of the distance columns.

Drop: 1%	1½%	2%	2½%	Wire Numbers; B. & S. Gauge:									
Distance; Feet.				1	2	3	4	5	6	8	10	12	14
60	90	120	150	...	...	..	..	..	..	..	..	..	16
66	99	132	165	...	...	..	..	..	..	..	..	23	15
72	108	144	180	...	...	..	..	..	..	..	..	21	13½
78	117	156	195	...	...	..	..	..	..	..	31	20	12½
84	126	168	210	...	...	..	..	..	..	46	29	18½	11½
90	135	180	225	...	...	..	..	..	69	43	27	17	10½
100	150	200	250	...	...	..	..	..	62	39	24	15½	9½
110	165	220	275	...	...	..	90	71	56	35	22	14	8¾
120	180	240	300	...	131	104	82	65	52	32	20½	13	8
130	195	260	325	154	121	96	76	60	48	30	18¼	11¾	7½
140	210	280	350	143	113	89	70	56	44	27	17½	11	7
150	225	300	375	133	105	83	66	52	41	26	16½	10¼	6½
160	240	320	400	125	98	78	62	49	39	24	15½	9½	6
170	255	340	425	117	93	73	58	46	36	23	14½	9	5¾
180	270	360	450	111	88	69	55	43	34	21	13¾	8½	5½
190	285	380	475	105	83	66	52	41	33	20½	13	8	5
200	300	400	500	100	79	62	49	39	31	19½	12	7½	4¾
220	330	440	550	91	72	57	45	36	28	17½	11	7	4½
240	360	480	600	83	66	52	41	33	26	16¼	10¼	6½	4
260	390	520	650	77	61	48	38	30	24	15	9½	6	3¾
280	420	560	700	71	56	44	35	28	22	14	8¾	5½	3½
300	450	600	750	66	52	41	33	26	21	13	8¼	5	3¼
320	480	640	800	62	49	39	31	24	19½	12	7½	4¾	3
340	510	680	850	59	46	36	29	23	18	11½	7¼	4½	2.9
360	540	720	900	55	44	34	27	22	17	10¾	6¾	4¼	2.7
380	570	760	950	52	41	33	26	20½	16½	10¼	6½	4	2.5
400	600	800	1000	50	39	31	24	19½	15½	9¾	6	3.8	2
420	630	840	1050	47	37	29	23	18¾	14¾	9¼	5¾	3.7	2.3
440	660	880	1100	45	36	28	22	18	14	8¾	5½	3.5	2.2
460	690	920	1150	43	34	27	21	17	13½	8½	5¼	3.3	2.1
480	720	960	1200	41	33	26	20½	16½	13	8	5	3.2	2
500	750	1000	1250	40	31	25	19¼	15¾	12½	7¼	4.9	3.1	1.9

TABLE IV.—USUAL MOTOR CURRENT.

The num :- in the body of the table are the Amperes required by Direct-Current Motors of Ordinary Efficiencies.

H.P.	Voltage for which the motor is designed: 110	115	120	125	220	230	240	250	500
¼	3	2.9	2¾	2.6	1½	1.4	1⅜	1.3	..
½	5½	5.3	5	4.8	2¾	2.6	2½	2.4	..
1	9	8.6	8¼	7.9	4½	4.3	4⅛	4	2
1½	13½	13	12½	11.9	6¾	6.5	6¼	6	3
2	17½	16.7	16	15.4	8¾	8.4	8⅛	7.7	3⅞
3	25½	24.4	23⅜	22.4	12¾	12.2	11¾	11.2	5⅝
4	33	31.6	30¼	29	16½	15.8	15¼	14.5	7¼
5	40	38.2	36⅔	35.2	20	19.1	18⅓	17.6	8⅞
6	48	45.9	44	42.2	24	23	22	21.1	10⅝
7½	58	55.5	53¼	51	29	27.8	26⅝	25.5	12¾
10	77	73.6	70	68	38½	36.8	35	34	16¼
12½	94	90	86	83	47	45	43	41½	21
15	114	109	104	100	57	54.5	52	50	25
20	150	144	138	132	75	72	69	66	33
25	188	180	172	166	94	90	86	83	41½
30	..	..	..	..	112	107	103	99	49½
35	..	..	..	..	130	124	119	115	57½
40	..	..	..	..	148	142	136	130	65
50	..	..	..	..	185	177	170	164	82
60	..	..	..	..	222	212	203	196	98
75	..	..	..	..	275	263	252	242	121
85	..	..	..	..	313	300	287	276	138
100	..	..	..	..	367	351	337	324	162

TABLE V.—MINIMUM WIRE SIZES.

The numbers in the body of the table are the B. & S. Gauge sizes of the Smallest Wires Permissible for feeding Direct-Current Motors of the Usual Efficiencies.

H.P.	Weather-proof Wire 110 v.	115 v.	220 v.	230 v.	500 v.	Rubber-covered Wire. 110 v.	115 v.	220 v.	230 v.	500 v.
1	14	14	14	14	14	14	14	14	14	14
1½	14	14	14	14	14	12	12	14	14	14
2	12	12	14	14	14	10	12	14	14	14
3	10	10	14	14	14	8	8	12	12	14
4	8	10	12	14	14	8	8	12	12	14
5	8	8	12	12	14	6	6	10	10	14
6	6	8	10	12	14	5	6	10	10	14
7½	6	6	10	10	14	4	4	8	8	12
10	5	5	8	8	12	2	3	6	6	12
12½	3	4	6	8	12	1	2	5	6	10
15	2	3	6	6	10	0	0	4	4	8
20	1	1	5	5	8	00	00	3	3	8
25	00	0	3	4	8	0000	0000	1	2	6
30	..	..	2	3	6	..	..	0	1	5
35	..	..	2	2	6	..	..	00	0	4
40	..	..	1	1	5	..	..	00	00	4
50	..	..	0	0	4	..	..	0000	000	2
60	..	..	000	00	3	..	..	300,000	circ. mils	1
75	..	..	0000	000	2	..	..	400,000	300,000	0
85	..	..	0000	0000	1	..	..	400,000	circ mils	00
100	..	..	300,000	circ. mils	0	..	..	500,000	circ. mils	000

TABLE III.

Current Required by Direct-Current Motors, at Different Efficiencies.

Commercial Efficiencies		110-Volt Motors ¼ h.p.	½	¾	1	1¼	1½	—	2	2½	3	—	5	6¼	7½	10	12½	15 h.p.
		220-Volt Motors ½ h.p.	1	1½	2	2½	3	—	4	5	6	7½	10	12½	15	20	25	30 h.p.
110 & 220 v.	500 volts	500-Volt Motors 1 h.p.	2	3	4	5	6	7½	—	10 h.p.	See heading in lower part of table.							
60	..	2.83	5.7	8.5	11.3	14.1												
61	..	2.78	5.6	8.3	11.1	13.9												
62	..	2.73	5.5	8.2	10.9	13.7												
63	..	2.7	5.4	8.1	10.8	13.5												
64	..	2.65	5.3	8	10.6	13.2												
65	..	2.6	5.2	7.8	10.4	13	15.7											
66	..	2.57	5.15	7.7	10.3	12.9	15.4											
67	..	2.53	5.1	7.6	10.1	12.7	15.2											
68	60	2.5	5	7.5	10	12.5	15	...	20	25	30							
69	61	2.46	4.9	7.4	9.8	12.3	14.8	...	19.7	24.6	29.5							
70	62	2.42	4.85	7.3	9.7	12.1	14.5	...	19.4	24.2	29	36.3	48.4	60.5	72.7			
71	..	2.4	4.8	7.2	9.6	11.9	14.3	...	19.1	23.9	28.7	35.8	47.8	59.7	71.7			
72	63	2.37	4.75	7.1	9.5	11.8	14.2	...	18.8	23.6	28.3	35.3	47.1	58.9	70.6			
73	64	2.33	4.66	7	9.3	11.7	14	...	18.6	23.3	29.9	34.9	46.7	58.1	69.7			
74	65	2.3	4.58	6.9	9.2	11.5	13.8	...	18.3	22.9	27.5	34.4	45.8	57.3	68.7			
75	66	2.26	4.52	6.8	9	11.3	13.6	...	18.1	22.6	27.1	33.9	45.2	56.5	67.8	90.4		
76	67	2.23	4.46	6.7	8.9	11.2	13.4	...	17.9	22.3	26.8	33.5	44.6	55.8	66.9	89.2		
77	68	2.2	4.4	6.6	8.8	11	13.2	...	17.6	22	26.5	33	44	55	66	88		
78	69	2.17	4.35	6.5	8.7	10.9	13	...	17.4	21.7	26.1	32.6	43.5	54.3	65.2	87	109	
79	..	2.15	4.3	6.4	8.6	10.8	12.9	...	17.2	21.5	25.8	32.2	42.9	53.7	64.4	85.9	107	
80	70	2.13	4.26	6.4	8.5	10.7	12.7	16	17	21.3	25.4	31.8	42.4	53	63.6	84.8	106	127
81	71	2.1	4.19	6.3	8.4	10.5	12.6	15.8	16.8	21	25.1	31.4	41.9	52.4	62.8	83.8	105	126
82	72	2.07	4.14	6.2	8.3	10.4	12.4	15.5	16.5	20.7	24.8	31	41.4	51.7	62	82.7	103	124
83	73	2.04	4.1	6.1	8.2	10.2	12.3	15.3	16.3	20.4	24.5	30.7	40.9	51.1	61.3	81.7	102	123
84	74	2.02	4.05	6	8.1	10.1	12.1	15.1	16.2	20.2	24.2	30.3	40.4	50.5	60.6	80.7	101	122
85	75	2	4	6	8	10	12	14.9	16	20	23.9	29.9	39.9	49.9	59.8	79.8	100	120
86	76	1.96	3.95	5.9	7.9	9.9	11.8	14.7	15.8	19.7	23.7	29.6	39.4	49.3	59.1	78.9	98.5	118
87	..	1.93	3.9	5.8	7.8	9.8	11.7	...	15.6	19.5	23.4	29.3	39	48.7	58.5	78	97.5	117
88	77	1.9	3.85	5.8	7.7	9.7	11.6	14.5	15.4	19.3	23.1	28.9	38.5	48.1	57.8	77.1	96.3	115
89	78	1.88	3.82	5.7	7.6	9.6	11.5	14.3	15.2	19.1	22.9	28.7	38.1	47.6	57.2	76.2	95.3	114
90	79	1.86	3.77	5.7	7.5	9.4	11.3	14.2	15	18.8	22.6	28.3	37.7	47.1	56.6	75.4	94.3	113
91	80	1.84	3.73	5.6	7.4	9.3	11.2	14	14.9	18.7	22.4	28	37.3	46.6	55.9	74.5	93.2	112
92	81	...	3.69	5.5	7.4	9.2	11.1	13.8	14.7	18.4	22.1	27.6	36.9	46.1	55.3	73.7	92.2	111
..	82	...	3.64	5.5	7.3	9.1	10.9	13.7	...	18.2								
..	83	...	3.60	5.4	7.2	9	10.8	13.5	...	18								
..	84	...	3.55	5.3	7.1	8.9	10.7	13.3	...	17.8								
											500-Volt Motors 12½	15	20	25	30	40	50	60 h.p.
..	85	...	3.5	5.3	7	8.8	10.5	13.2	...	17.6	21.9	26.3	35.1	43.9	52.7	70.2	87.8	105
..	86	...	...	..	6.9	8.7	10.4	13	...	17.4	21.7	26	34.7	43.4	52.1	69.4	86.8	104
..	87	...	...	..	6.9	8.6	10.3	12.9	...	17.2	21.5	25.7	34.3	42.9	51.5	68.6	85.8	103
..	88	...	...	..	6.8	8.5	10.2	12.7	...	17	21.2	25.4	33.9	42.4	50.9	67.8	84.8	102
..	89	...	...	..	..	...	10	12.6	...	16.8	20.9	25.2	33.5	41.9	50.3	67	83.8	101
..	90	...	...	..	..	...	9.9	12.4	...	16.6	20.7	24.9	33.2	41.5	49.7	66.3	82.9	99.5
..	91	...	...	..	..	...	...	12.3	...	16.4	20.5	24.6	32.8	41	49.2	65.6	82	98.4
..	92	...	...	..	..	...	...	12.2	...	16.2	20.3	24.3	32.4	40.6	48.7	64.9	81.1	97.3

Note: As the numbers in the body of the table have been restricted to three figures, it occasionally occurs that the same current value must be given for two different efficiencies; *e. g.*, 3-h.p. 500-volt motor of 81 % and 82 % efficiency.

In a large majority of cases, where only one or two motors are installed and the distances are short, the smallest size of weather-proof wire allowable under the Underwriters' Code will be large enough to keep the drop within reason. Table VI shows the distances at which motors of average efficiencies may be served with drops of 1 per cent. and 3 per cent., using the smallest permissible sizes of wire in each case (the sizes specified in Table V). The reader will of course understand that the distances for 2 per cent and 5 per cent drop may be ascertained by simply multiplying the 1 per cent distances by 2 and 5 respectively; 4 per cent distances may be determined by inspection—adding the 1 per cent and 3 per cent distances together. It will usually be found more convenient, however, to divide the real distance by the desired drop, and find the result in the 1 per cent column, if a definite drop limit other than 1 per cent or 3 per cent is imposed. If none is imposed, then divide the actual distance by the distance number in the 1 per cent column, and the result will be the approximate drop that will be sustained.

TABLE VI.—MAXIMUM DISTANCES FOR MINIMUM WIRE SIZES.

The numbers in the body of the table are Distances, in feet, to which Direct-Current Motors of Average Efficiencies may be supplied over the Smallest Permissible Sizes of Wire, with the Drops specified in the headings.

H.P.	Weatherproof Insulated Wires										Rubber-covered Wires									
	One per cent drop					Three per cent drop					One per cent drop.					Three per cent drop				
	110 v.	115 v.	220 v.	230 v.	500 v.	110 v.	115 v.	220 v.	230 v.	500 v.	110 v.	115 v.	220 v.	230 v.	500 v.	110 v.	115 v.	220 v.	230 v.	500 v.
1	4½	5	18	20	96	14	15	56	61	290	4½	5	18	20	96	14	15	56	61	290
1½	3	3	12	14	64	9	10	37	41	193	5	5	12	13	64	15	16	37	41	193
2	3½	4	9	10	49	11	12	28	31	147	5½	4	9	10	49	17	12	28	31	147
3	4	4	6½	7	34	12	13	20	21	103	6	6½	10	11	34	18	20	31	34	103
4	4½	3	8	5	26	14	10	24	16	78	4½	5	8	8½	26	14	15	24	26	78
5	3½	4	6½	7	22	11	12	20	22	66	6	6½	10	11	22	18	20	32	35	66
6	5	3	8	6	18	15	10	26	18	55	6½	5	8½	9½	18	20	16	26	29	55
7½	4	4½	7	8	15	12	14	22	24	45	7	8	10	11	24	22	24	32	35	72
10	4	4½	8	8	18	13	14	24	26	54	8½	7½	12	14	18	26	23	38	42	54
12½	5½	5	10	7	14	17	15	31	21	44	9	7½	14	11	26	27	23	43	34	70
15	6	5	8	9	19	18	15	26	28	58	9	10	15	16	28	28	31	45	50	85
20	5½	6	9	9½	21	17	19	27	29	64	9	9½	14	15	21	27	29	43	47	64
25	6	6	11	10	17	19	19	34	30	51	10	12	18	15	27	30	37	55	47	81
30	.	.	12	10	22	..	..	36	32	68	..	..	19	17	31	..	..	58	51	93
35	.	.	10	11	19	..	..	31	34	59	..	..	21	18	34	..	..	63	54	103
40	.	.	11	12	23	..	..	35	38	71	..	..	18	20	30	..	..	55	60	90
50	.	.	11	12	24	..	..	35	38	72	..	..	23	20	38	..	..	70	61	114
60	.	.	15	13	25	..	..	46	40	76	..	..	27	30	40	..	..	83	91	122
75	.	.	15	13	25	..	..	47	41	77	..	..	29	24	41	..	..	89	73	123
85	.	.	13	15	28	..	..	41	45	86	..	..	26	28	45	..	..	78	85	135
100	.	.	16	18	31	..	..	50	55	93	..	..	27	30	48	..	..	83	91	146

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A FEW POINTS IN MOTOR OPERATION.

BY GEO. W. MALCOLM.

As has been stated often before the shunt-wound direct-current motor is a patient, long-suffering piece of machinery, frequently roasting its armature winding to a state of disability in an uncomplaining effort to do all the work that is foolishly piled on it, instead of quitting as soon as the overload becomes excessive, as does its alternating-current relative, the induction motor. With all its excellent qualities, however, the direct-current motor is occasionally found giving freakish performances, which are sometimes difficult to analyze; but it is only fair to state that these are invariably due to abnormal conditions and not to any bad qualities in the motor itself.

A case came within the writer's knowledge recently in which a plain shunt-wound motor sometimes increased its speed with an increase in load and on the other days showed a falling off in speed of over 15 per cent between no load and full load. There was no heating or sparking, no sign of abnormal conditions, excepting the contradictory speed variations. While discussing the curious performance, the superintendent of the shops laid his hand in the handle of the rocker-arm by which it is adjusted circularly, and it yielded to the pressure, having been evidently left insecurely set. The brushes were thrown a couple of inches ahead of their original position, and the speed of the motor increased perceptibly, the tone of the hum rising to a high pitch. Investigation disclosed the fact that if the brushes were given a forward lead, the speed would increase as the load increased, while an opposite lead produced the opposite effect. It further transpired that a boy was required to wipe down the motors every morning before starting them up, and cross-questioning brought out the fact that for some reason only comprehensible to the juvenile mind, he sometimes left the rocker-arm handle thrown forward and sometimes the other way.

In another instance, a compound-wound motor, after having operated smoothly for a day or so, went up to nearly double its normal speed. The machine was shut down, of course, and tested for "grounds" and other troubles which could not have caused the excessive speeds, but no unusual condition was discovered. Upon being started up again, the machine took its normal speed, but in a few minutes, without having been touched, swooped up almost to double speed. The trouble eventually proved to be due to the remarkable coincidence of one shunt coil (it was a four-pole machine) being connected up backwards and the opposite ends of two neighboring coils being crossed with the series coils so as to practically short-circuit the reversed shunt coil, except when the cross jarred loose sufficiently to allow it to get current. With the cross "on," cutting out the improperly connected coil, the motor ran normally, but when the connection jarred loose, putting the reversed coil in circuit, that coil neutralized the effect of one of the other field coils, and the armature coils were cutting only little more than half of the magnet flux in the proper direction; the counter e. m. f. was therefore a little more than half the normal, so that the speed was nearly doubled. The armature winding was of the two-path type.

In these days of systematic manufacturing processes, there is little excuse for wrong commutator connections, but these occur occasionally, and it is well to remember that each coil connected up backwards will neutralize one of the coils that is properly connected, and thereby cause the armature to run at a speed higher than the rated speed. This trouble is not likely to be found in new motors; when it occurs it is almost always in a motor that has had armature coils replaced. It will not be noticeable unless several coils are connected backwards. If one-tenth of the total number of coils should be reversed, one-fifth will be ineffective, and the speed will be raised one-fourth above normal, while the torque will be reduced to four-fifths of the normal torque.

In a machine, either motor or generator, working near its sparkless limit, vicious sparking may readily be caused by irregular thicknesses of commutator segments and the mica strips between them. Looseness of brush-holder rigging which allows the brushes to vary the distance from brush to brush around the commutator is also a prolific source of sparking in machines without a goodly margin of sparklessness. (The writer is well aware that the ability of a modern dynamo or motor is supposed to be limited only by heating; the supposition, however, is not always in accord with the performance.)

In setting the brushes of a machine on which each brush-holder stud is adjustable toward or away from the neighboring stud, it is a good rule to cut a strip of paper of such length that when it is wrapped once around the commutator barrel the two ends meet precisely, without lapping; then divide it by pencil lines into as many parts as there are magnet poles, wrap it around the commutator and set the brushes by the marks. The writer's preference is for machines that cannot be "monkeyed with" in this particular; a machine should have its brush-holders secured permanently with the proper spacing when it is first sent out, and the brush-holders should not be capable of any adjustment, except along an exactly radial line toward or away from the commutator, and the usual adjustment of the entire brush rigging in a circular direction.

Lessons in Practical Electricity

LOSSES IN DYNAMOS AND MOTORS.

The losses incurred in converting energy by means of a dynamo or a motor are due to four distinct causes, namely, mechanical resistance or friction, electrical resistance, hysteresis or magnetic inertia as it is sometimes called, and eddy currents. The student undoubtedly understands what mechanical friction is, and electrical resistance and hysteresis have been explained in previous Lessons. Eddy currents are currents that are induced in metal portions of the machine where they serve no useful purpose. The iron surface of an armature core, for example, is constantly cutting lines of force, exactly as do the armature conductors. Consequently, an e.m.f. is induced in the metal which would cause a heavy current to circulate through the armature core if no precautions were taken to prevent it. In practice, the armature core is built up of thin sheet iron cut into discs or rings, according to the type of construction. The discs or rings are coated with some insulating material, so that there is no longer a continuous path of metal through the core parallel with the shaft. This diminishes eddy currents tremendously, but does not prevent them entirely, because they can still find a circuit within each individual disc. Fig. 1 shows how eddy currents would circulate in a bipolar armature if the core were made of four very thick discs. The discs of a modern armature core are from 20 to 40 mils* thick, only, so that the eddy currents are very small.

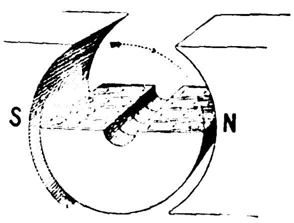

FIG. 1.—EDDY CURRENTS IN CORE DISCS.

Eddy currents are also induced in the pole-faces of the field magnet, when toothed armatures are used (and they almost invariably are), by reason of the fact that the magnetic flux passes between the pole-face and the armature teeth in tufts, and the teeth drag these tufts across the pole-face, as indicated in Fig. 2, where only one tooth is shown. The result is a flow of eddy currents somewhat as indicated by the dotted lines in Fig. 3. In order to reduce this action, magnet poles are now frequently built up of iron plates 25 to 50 mils thick. The flow of eddy currents represents a waste of power because an expenditure of power is necessary to produce any flow of current, and the eddy currents are not useful in any way.

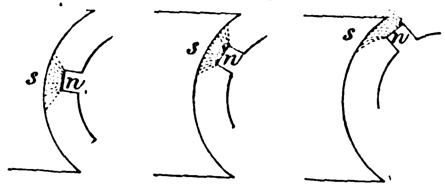

FIG. 2.—ALTERATION OF MAGNETIC FIELD.

As an armature core revolves under the field-magnet poles of a motor or a dynamo, the direction of the magnetic flux through the teeth and core is constantly changing, and these changes cause a waste of power by hysteresis, power being required to change the magnetic polarity of iron and steel. This waste and the eddy-current waste are commonly lumped together under the term "core-losses" or "iron losses," although they do not vary in the same manner. The power wasted by eddy currents is proportional to the square of the magnetic flux density in the iron, the square of the number of times that the polarity is reversed per second, and the square of the thickness of the core discs. The waste due to hysteresis is proportional to the 1.6th power of the magnetic density and to the rate of reversal in polarity. For example, if an armature with core discs 20 mils thick, a magnetic flux density of 60,000 lines per square inch in the core and a rate of 15 complete reversals of polarity per second, showed a loss of 100 watts due to hysteresis and 30 watts due to eddy currents, an increase of speed such as would produce 20 reversals per second would increase the hysteretic loss to 133 watts, while the eddy-current loss would be increased to 53 watts—nearly doubled. Or, if the speed remained unchanged and the magnetic density were raised to 75,000 lines per square inch, the waste due to hysteresis would be increased to about 143 watts and that due to eddy currents would go up to 47 watts. Again, if the core were made up of discs 40 mils thick instead of 20, the hysteretic loss would be the same as with the 20-mil discs, but the eddy-current loss would be quadrupled.

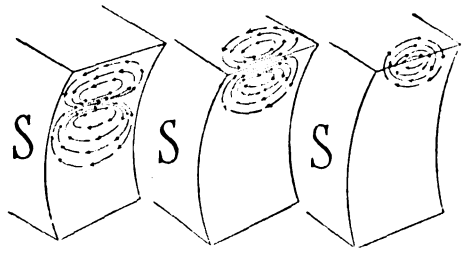

FIG. 3.—INDUCED EDDY CURRENTS.

The waste of power by electrical resistance occurs in both the armature and the field-magnet coils, and follows the law regarding the loss of energy due to the passage of current through any conductor, *i. e.*, the loss in watts is equal to the square of the current multiplied by the resistance of the conductor. In formula shape,

$$I^2R = \textit{Watts lost},$$

in which I is the current in amperes and R is the resistance in ohms of the path through which the current passes.

The waste of power by mechanical friction is not susceptible of accurate calculation. It is a very small proportion of the total loss in a properly-built and well-attended machine, as friction occurs only in the bearings, between the commutator and brushes, and wherever uneven parts of the armature move rapidly through the air—this latter loss being sometimes termed "windage."

The total loss or waste of power in a dynamo or motor then, may be expressed symbolically as follows:

$$P_r + P_h + P_c + P_f = P_w.$$

P_r representing losses in the windings and electrical connections; P_h the waste by hysteresis; P_e the waste due to eddy currents, and P_f the friction loss, all being expressed in watts. The sum of all these is written P_w to indicate "power wasted."

All of the energy lost by the causes just mentioned appears in the form of heat. The power lost in overcoming the resistance of the field-magnet and armature windings causes a very perceptible rise of temperature in those parts; the power wasted by hysteresis and eddy currents produces similarly a rise of temperature in the iron where these losses occur, and as every reader undoubtedly knows, the temperature of a bearing, or any other pair of surfaces moving in contact with each other, is always elevated by the resulting friction. In practice, the resistance and friction losses usually occasion the greatest rise in temperature; in a well-designed machine the rise in temperature due to hysteresis and eddy currents can scarcely be noticed even by applying the hand to the surface of the armature core.

The resistance loss in the field may be determined very readily by measuring the current in the field winding and multiplying it by the voltage at the terminals ($E = I\ R$; therefore, $I\ E = I \times I\ R$, *or* I^2R). The loss in the armature circuit may be determined by running the machine at full load for an hour or two, then stopping it and passing full-load current through the armature with the latter held stationary (the field circuit should be opened, so that no current can get through it) and measuring the difference of potential at the terminals of the machine; multiplying this difference of potential by the full-load current gives the loss in watts in the armature circuit, including the series field winding, if there is one. Adding this result to the loss in the shunt field winding gives the total resistance loss *Pr*.

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* A mil is one-thousandth of an inch.

It is not possible to separate the losses due to friction, hysteresis and eddy currents, except by means of complex tests and curve plotting which the student of these Lessons will not yet have progressed far enough to grasp. For all practical purposes of operation there is no need to separate these three losses; the sum of the three may be ascertained with sufficient accuracy by running the machine as a motor (whether it be one or a dynamo) without any load, measuring the watts delivered to the armature, and deducting therefrom the watts lost by resistance in the armature circuit under this condition—not the full-load loss. Thus, with the machine running "free," measure the armature current and multiply it by the voltage at the brush-holders; this will be the total watts delivered to the armature. Then shut down, open the field-circuit, and with the armature held stationary, pass through it exactly the same current that it took while running free, and measure the volts at the brush-holders. Multiply the voltage and current together, subtract this result from the first one, and the remainder will be the combined core and friction losses in watts.

If the machine is a motor, no precautions will need to be taken as to the regulation of the field current beyond making sure that the voltage at the terminals is the rated voltage of the machine. If it be a dynamo, however, it must first be driven as a dynamo, under full load, with the series winding cut out and the shunt current adjusted to give the proper full-load voltage at the brushes; then the volts at the shunt winding terminals must be measured and recorded. The machine should then be driven as a motor, with the shunt field excited at the voltage just recorded and at precisely the normal dynamo speed, to make the test for core losses and friction. In order to get the armature up to normal dynamo speed it will be necessary to supply it from a source giving an e.m.f. considerably higher than the rated e.m.f. of the machine. Adjustable resistances must be used in the armature and field circuits to obtain the proper speeds, currents, etc., for the various tests.

Having ascertained the internal and friction losses of the machine, its efficiency in percentage, if a motor, may be calculated by means of the formula—

$$100 - \frac{100\ P_w}{P_t} = e \qquad (1)$$

in which P_t represents the total watts delivered to the machine from the supply circuit, when running at full load. If it is a dynamo, the percentage of efficiency will be given by the formula

$$\frac{100\ P}{P + P_w} = e \qquad (2)$$

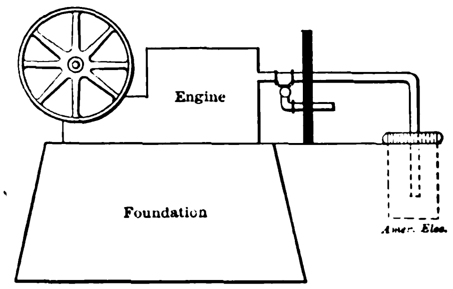
in which P is the output of the machine in watts.

Letters on Practical Subjects

A Home-Made Gas Engine Exhaust Muffler.

To the Editor, American Electrician:

Thinking that some of your readers would like to know of a cheap but effective gas engine exhaust muffler, I submit the accompanying sketch, which shows an arrangement that I have found to be very satisfactory. The muffler consists of a piece of sewer pipe about 10 inches in diameter and 2 feet long, set in the ground just outside the wall of the engine room, as indicated in the sketch. The exhaust pipe of the engine enters the muffler through a wooden cover, which is perforated with a number of ½-inch holes. A branch is led off from the exhaust pipe and opens into the air, a valve being inserted at the junction of this pipe with the exhaust pipe. This is for the purpose of relieving the cylinder of back pressure at the time of starting up, and also in case the holes in the muffler cover become closed up with snow or ice between the time of shutting down and starting up. After a few explosions, the relief valve is closed. This muffler has been found to suppress the sound of the exhaust almost completely.



GAS ENGINE EXHAUST MUFFLER.

Another wrinkle which may be of interest to the reader consists of supplying a small radiator with the water discharged from the water jacket of the engine, thus cooling the discharge water, and at the same time contributing to the heating of the room. The engine to which these features were applied is a 3-h.p. machine, operated on gasoline; the radiator is made up of ½-inch pipe.

E. S. LINCOLN.

Brookline, Mass.

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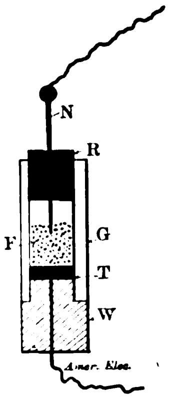
A Simple Wireless Telegraph Coherer.

To the Editor, American Electrician:

I have developed a wireless telegraph coherer which differs in some points from anything that I have seen described in the electrical publications, and, thinking that your readers might find a description of it of some interest, I send herewith a sketch of it.

Referring to the sketch, *G* is a glass tube mounted on a piece of soft wood, *W*, which has a boss turned on its upper surface. On the end of the boss is a layer of tinfoil, *T*, which is connected to one of the leading-in wires. On the tinfoil is placed a quantity of fine filings, *F*, into which the point of an ordinary sewing needle, *N*, projects. The needle constitutes the other terminal of the coherer and is mounted in a soft rubber stopper, *R*; this needle is heavily magnetized. The filings are made up of nine parts coin silver and one part soft iron; part of the iron filings form a sort of brush on the point of the magnetized needle. The sensitiveness of the coherer may be adjusted within certain limits by varying the depth to which the point is buried in the filings. I have made a large number of coherers of various kinds, and have found this to be the most sensitive of the lot and the easiest to decohere.



COHERER.

I have used a coherer built in the manner just described for observing the electrical condition of the atmosphere, with interesting results. I mounted the coherer on the lever of an ordinary telegraph sounder, the sounder being actuated in the usual manner by a local circuit controlled by a 1,000-ohm telegraph relay. The coherer was inserted in the magnet circuit of the relay, one terminal of which was carried to an aerial wire 40 feet high. The relay and sounder begin to chatter usually about five or six hours before a storm breaks.

Mesa, Ariz. F. W. CERNY.

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Mr. Fisk's Problem in Telephone Connections.

To the Editor, American Electrician:

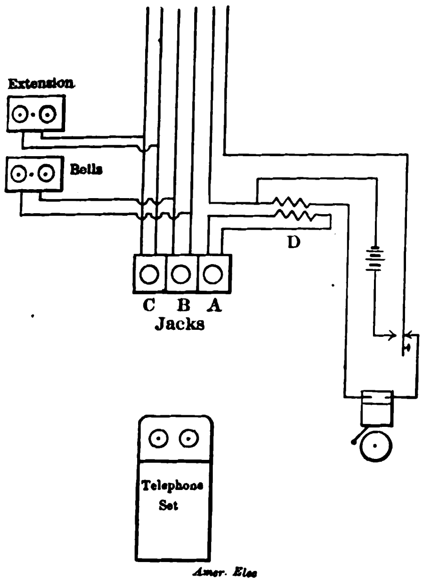
The accompanying diagram is submitted as a solution to Mr. Fisk's telephone wiring problem, which appeared in the November number of the AMERICAN ELECTRICIAN. As the diagram shows, the call-bell circuit is maintained independent of the telephone circuit, *A*, by means of a repeating coil, *D*, through which telephonic current impulses are transmitted between the circuit and the jack. The other circuits, *B* and *C*, are provided with ordinary extension bells made to give different tones, or otherwise arranged for identification. The local telephone set is, of course, plugged into any one of the three circuits at the jacks, *A*, *B*, *C*.

If that part of the repeating-coil winding which is in the call-bell circuit has too great a resistance for the successful operation of the call-bell, a relay may be interposed between the circuit and the bell.

Bucyrus, Ohio. W. E. STIEFEL.

To the Editor, American Electrician:

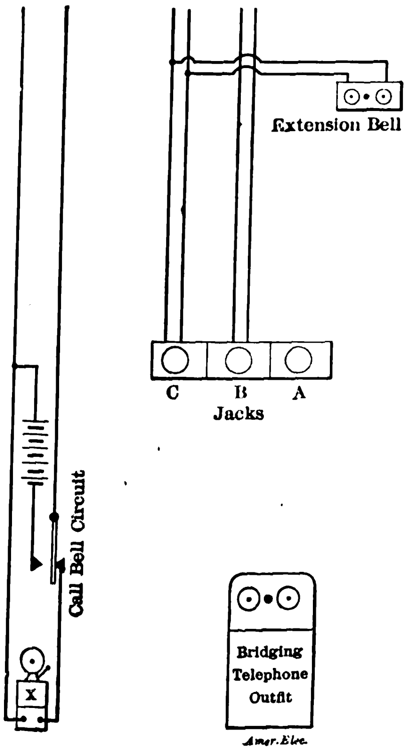
Referring to Mr. Edwin R. Fisk's problem published in the November number, I suggest that this may be solved by simply grounding one side of the jack, *A*, connecting the other side to one of the call-bell circuit wires and grounding that wire through the telephone instrument at the other tower. In other words, one side of the call-bell circuit will serve also as the line wire of the telephone circuit, the latter being grounded at each end. The local telephone instrument may be, of course, plugged into any one of the three jacks, and signals from the two purely telephonic lines may be received by extension bells permanently connected to those lines.



MR. STIEFEL'S SOLUTION.

William A. Loveland.
Philadelphia, Pa.

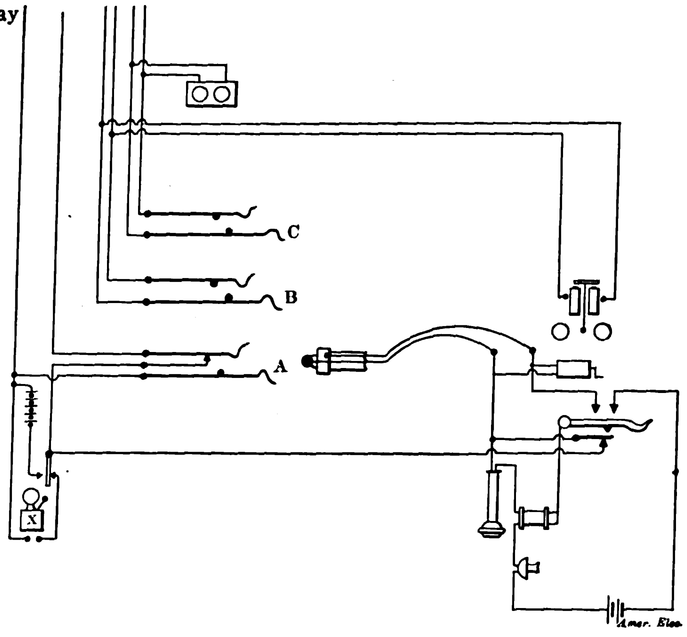
[Practically the same solution as Mr. Loveland describes was sent in by Charles Morrison, San Mateo, Cal.—Editor.]



MR FISK'S ORIGINAL DIAGRAM.

To the Editor, American Electrician:

The accompanying diagram shows the manner in which the problem that you published for me in the November number was actually solved. The connections inside the local telephone set were changed as indicated in the diagram, and the jack, *A*, was of the type illustrated. When the instrument is plugged into the call-bell circuit, so long as the hook-switch is down the right-hand side of the circuit is continuous through the tip strand and the lower contacts of the hook-switch. The fact that the sleeve of the plug is connected to the left-hand side of the call-bell circuit does not interfere with the operation of the call-bell.



MR. FISK'S SOLUTION.

The signalling bell on the telephone set was disconnected from the set and connected to the line, *B*, as shown, while the line, *C*, was provided with an ordinary extension bell.

Edwin R. Fisk.
West Springfield, Mass.

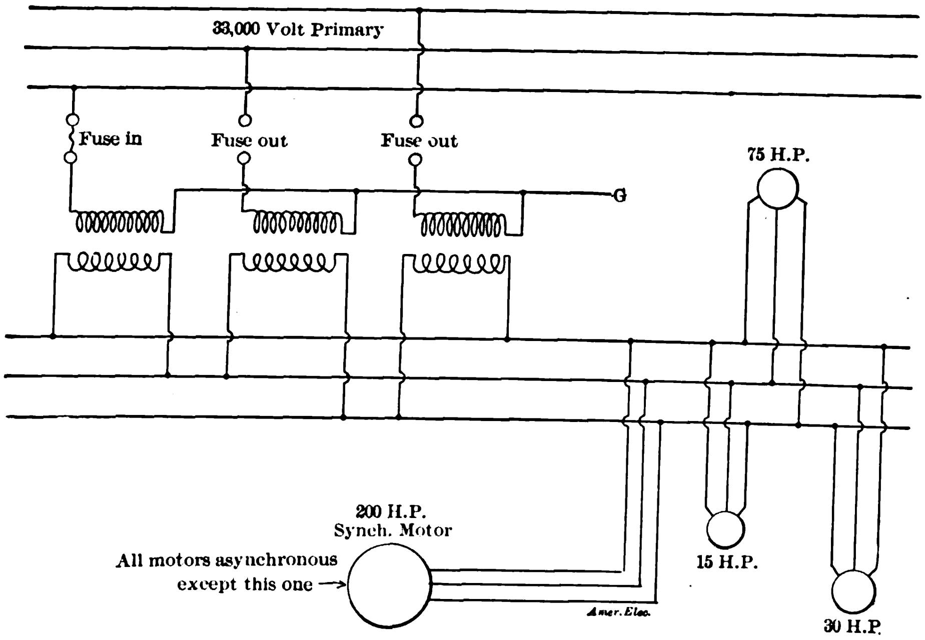
Mr. Benjamin's Problem in Alternating-Current Operation.

To the Editor, American Electrician:

The explanation of the actions described by Mr. F. P. Benjamin in the December number of your paper appears very simple to the writer. Referring to his diagram, it is evident that the circuit between the generating station and the primary of the left-hand transformer was completed through the ground; the fact that the ground ammeter at the generating station showed 8 amperes is sufficient proof of this, even if the connections did not make it perfectly clear. There was impressed upon the primary of this transformer, therefore, a potential of $33{,}000 \div \sqrt{3} = 19{,}100$ volts, and the synchronous motor being brought up to speed and thrown on the circuit, operated as a single-phase motor at the reduced potential and also as a phase transformer, supplying the current for the other two phases of the induction motors.

Chicago, Ill. **William F. Dean.**

[The same explanation, which is, of course, correct, has been sent in by Geo. A. Burnham, Winchendon, Mass.; Leslie Carpenter, New York; Fred A. Fish, Columbus, Ohio; Henry Mulford, Patchogue, L. I.; Geo. Noble, Three Rivers, Calif.; James A. Scott, Wilkinsburg, Pa., and George Stanley, Ithaca, N. Y.—Editor.]



MR. BENJAMIN'S PROBLEM.

Electrical Catechism

718. What causes affect the color of the gold deposit?

In the operation of gilding, the color may be influenced almost momentarily in several ways. Assuming that the current of electricity is neither too strong nor too weak and the bath is in perfect order, if too small a surface of anode is immersed in the bath the gold deposit will be of a pale yellow color. If on the other hand too large a surface of anode is exposed in the solution, the deposit may be of a dark brown or "foxy" color; whereas, the mean between these two extremes will cause the deposit to assume the rich orange yellow color of fine or pure gold. The color of the deposit may be greatly affected by the motion of articles while in the bath; for example, if the gilding be of a dark color, by moving the article about in the bath it will quickly assume the proper color. The temperature of the solution also affects the color of the deposit, the tone being deeper as the solution becomes warm, and *vice versa.* The color of the gilding is likewise much affected by the nature of the current employed. A weak current from a Daniell cell may cause the deposit to be of a paler color than is desirable; whereas, the current from a Smee, Grove or Bunsen cell (more especially the latter) will produce a deposit of a far richer tone. The presence of other metals in the solution—copper and silver particularly—will alter the color of the deposit, and it is therefore of importance to keep these metals out of the ordinary gilding solutions by careful means. The color of the gilding is greatly affected by the accumulation of organic matter; that is, vegetable or animal matter which is introduced into the bath by the articles immersed in it. Thus, greasy matter from polished work and beer from the scratch-brush will sometimes lodge in the interstices of hollow work and escape into the bath even after the articles have been rinsed. Each in turn conveys organic matter to the gold solution by which it acquires a dark color, almost at times becoming a pronounced brown.

719. How are the interiors of vessels plated with gold?

The inside of the vessel is first well scratch-brushed, for which purpose a special scratch-brush known as an "end brush" is used. If such be not easily accessible, the surface may be scoured with soap and water with a piece of stout flannel and the vessel well rinsed. The vessel is then placed upon a level table or bench, and a gold anode turned up in the form of a cylinder is connected to the positive electrode of the battery, lowered into the vessel and operated in this position, care being taken that it does not touch the vessel at any point. The negative electrode is placed in contact with the vessel, and a hot gold solution is then carefully poured in until the solution reaches the extreme inner edge below the mount. A few moments after pouring in the gold solution, the anode should be gently moved to and fro without coming in contact with the vessel itself, so as to make the deposit more uniform. It may then be allowed to remain without interruption for a minute or so, when the gentle movement of the anode may be renewed for a few moments, these alternations of motion and repose being kept up for about five or six minutes, or perhaps a little longer, by which time a sufficiently stout coating is generally obtained. The occasional moving of the anode has the effect of rendering the deposit more regular, while it also exposes a fresh surface of the solution to the metal surfaces under treatment. It will be necessary, however, to exercise considerable care to avoid driving the solution over the mount or the rim of the vessel. The lips of ewers, which the gold solution cannot reach when the vessel is filled with solution, are plated by conducting the solution to such parts in the following manner: A small gold anode with a short piece of copper wire attached is enclosed in a piece of chamois leather. The end of this wire is then connected with the positive electrode, the article itself being in direct contact with the negative electrode, and the chamois pad, or "Doctor," as it is called, is dipped in the gold solution and applied to the part to be gilded. In this way, by repeatedly dipping the pad in the solution and conducting it over the surface, the lips of ewers are gilded in a short time; but since this is the most important part of the gold surface, the applications should be continued until a sufficiently thick deposit is obtained, care being taken that the joint between the two deposits is not visible when the gilding is completed. For this reason it might be preferable to first gild the lips of vessels, and after well scratch-brushing or scourinig the interior—especially where the two gildings will meet—to gild the interior of the vessel and finally scratch-brush the whole surface. In gilding the interior of vessels, it is of paramount importance that the outsides and mounts should be perfectly dry; otherwise, the gold solution may pass beyond its proper boundary and gold will be deposited where it is not required and where it will entail some little trouble and annoyance to remove it.

720. How are the different colors of gold obtained?

It might easily be imagined that gold, when deposited from its solution upon another metal, would necessarily assume its natural color, that is, a rich orange yellow. That such is not the case is well known to all who have practised the art of gilding, and the effect may be easily demonstrated by first gilding a piece of German silver with a cold cyanide solution of gold and then raising the temperature to about 130° F. If now a similar piece of metal be gilded in a warm solution and the two surfaces compared, it will be found that while the deposit from the cold solution is of a pale yellow color, that obtained from the warm solution is of a deeper and richer hue. A very deep-colored deposit of gold may be obtained in an old-gold solution in which organic matter has accumulated from imperfect rinsing of the work and in which there is a good proportion of free cyanide, by employing a strong current and exposing a large anode surface. In this case the deposit is of a "foxy" color, as it is termed, and when scratch-brushed, exhibits a depth of tone, which, while being unsuited for most purposes, may be useful in a variety of some kinds of fancy gilding where a strong contrast of colors is desired. The movement of an article in the solution also affects the color of the gold deposit, sometimes in a very remarkable degree, the color being lighter when the article is moved about and dark when the article remains at rest. These conditions, however, are more marked with old and dark color solutions than with recently prepared solutions or such as have been kept scrupulously free from the introduction of organic impurities. For ornamental work, as in cases where chased or engraved silver or plated ware is required to present different shades of color on its filleted surfaces, solutions of gold may be prepared from which the various tints may be obtained by electrodeposition. These solutions are formed by adding to ordinary cyanide gilding baths varying proportions of silver or copper solution, or both, as also solutions of other metals; but in order to insure uniformity of results, the solutions should be worked with anodes formed from an alloy of the same character, or at least, if an alloy of silver and gold, for example, is to be deposited, an anode of gold and one of silver should be employed in order to keep up the condition of a joint solution. Green gold is obtained by adding a solution of double cyanide of gold and potassium and a small proportion of cyanide of silver solution until the desired tint is obtained. This solution should be worked preferably cold, or nearly so. Red gold is obtained by adding to a solution of cyanide of gold a small quantity of cyanide of copper solution and employing a moderately strong current. It is best in making these additions to begin by adding a very small proportion of the copper solution first and then increase the quantity gradually until the required tint is obtained, since an excess of the copper solution produces a deposit of too coppery a hue. The tint generally required would be that of the old-fashioned gold and copper alloy, with which the watch cases of the last, and early part of the present, century were made. Pink gold is obtained by first gilding the article in the usual way, then depositing a slight coating in the preceding bath, and afterwards depositing a mere pellicle of silver in the silvering bath. The operation requires great care to obtain the desired pink tint. The article is afterwards burnished, but since silver is readily colored or oxidized, as it is termed, unless properly protected by a colorless varnish, the effect will not be of a permanent character. Pale straw-colored gold may be obtained by adding to an ordinary cyanide solution a small quantity of silver solution and working the compound solution cold with a small surface of anode and a weak current.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Why cannot two-phase or three-phase currents be transmitted over two conductors? F. H. B.

Because more than one current cannot pass simultaneously through a single conductor.

Is electric welding practicable, taking current from an ordinary 110-volt incandescent circuit, for small articles up to about 1 inch in diameter? C. E. C.

No; it is possible, of course, but only with enormous waste of energy.

Does copper wire become brittle by the passage of current over it? C. W. R.

Not unless the current is so heavy as to heat the wire enormously and the latter is subjected to sudden cooling after each passage of current over it, as in the case of a submerged rheostat.

How can a transformer wound to give 32 volts at the secondary terminals be changed so as to deliver 100 volts? F. L. S.

By substituting a secondary coil wound of wire of one-third the cross-section of the present wire and with 3⅛ times the number of turns in the present secondary coil.

Please give data for an induction coil to give a ½-inch spark. F. B.

Core ⅝ inch diameter, 5 inches long, made of No. 22 annealed iron wire; primary winding, three layers of No. 16 double cotton-covered wire; secondary winding, 12 ounces of No. 36 double silk-covered wire; 40 condenser sheets of tinfoil 4 x 5½ in.

Where can I obtain sheet-iron stampings for the armatures of the "universal" machine described in "Electrical Designs"? J. V. D.

So far as we know, these cannot be obtained on open market, nor can any other of the armature stampings described in the book. The market for special stampings of this sort is too limited to justify their commercial manufacture.

Why are the ends of the core of an induction coil allowed to project beyond the ends of the coil? (2) What advantage has a Nernst lamp over an ordinary incandescent lamp on an alternating-current circuit? I. B.

In order to reduce the reluctance of the magnetic path in air where the lines of force emerge from the ends of the core. (2) It has higher efficiency and gives a more beautiful quality of light.

As an incandescent lamp grows old, it gives less light; does its resistance increase or decrease? (2) If the resistance increases, why does the power consumption in watts per candle increase, and if the resistance decreases, why does not the filament burn out? E. W.

The resistance of the filament increases, so that the actual current consumption decreases, but the candle-power decreases more rapidly than the current consumption; consequently, the watts per candle increase.

How much resistance is it customary to put in series with street car motors of different sizes? (2) What is the resistance of track rails used in the return circuit of a railway plant? (3) Are electroplating dynamos always shunt wound? A. F.

There is no rule that will apply generally; the resistance is calculated for the class of service that the motors are to perform. (2) The resistance of 90-pound steel rail is about 0.000005 ohm per foot. (3) No; most platers now-a-days are compound wound.

Should the armature coils of a four-pole direct-current motor, having 71 armature slots, be located in slots 1 and 19, 19 and 37, 37 and 55, etc? (2) Why are the armature coils of a bipolar motor not put each in diametrically opposite slots? E. T. Z.

This spacing may be used and frequently is, but it would be slightly preferable to put the coils in slots 1 and 18, 18 and 35, 35 and 52 and so on. (2) In order to reduce the extent of the bunching where the coils cross each other on the armature heads.

Why is it that a longer arc is drawn at the switch when the primary circuit of a constant-current transformer is opened with the secondary short-circuited than when it is opened with the transformer normally loaded? R. E. Y.

Because the current is greater when the secondary is short-circuited than when the transformer is normally loaded. Moreover, the secondary current is not rigidly constant; it is greater under short-circuit than under normal load, so that the increase in the primary current is enhanced.

Would office wire be better for the primary winding of an induction coil than cotton-covered wire? (2) Can a 50-c.p. Nernst lamp be lighted from an induction coil? (3) When the sliding tube of an induction coil is put half way over the coil, does it increase or decrease its strength? (4) What length of pipe will be necessary to hold one pound of water, the bore of the pipe having one square inch area? A. S. D.

No. (2) No. (3) With the tube entirely off, the strength of the coil is at its maximum. As the tube is slipped over the coil, the strength is gradually reduced. (4) 2.309 feet.

What is meant by the "thermal coefficient" of an engine, and what is its value? A. S. V.

The thermal coefficient is the ratio between the amount of heat turned into useful work and the total amount of heat produced. It amounts to almost 20 per cent and rarely exceeds 25 per cent. These are, comparatively speaking, very high figures, even when compared with those obtained with a triple expansion engine of the most improved type and utilizing the highest possible pressures and steam superheated 350°. With a coal consumption of 1½ pounds per horse-power, the thermal coefficient does not rise above 12 per cent.

Is there any way to measure resistance with a volt-ammeter? D. A. W.

Not reliably; if an absolutely steady source of current is available, it can be done by passing current through the resistance and the ammeter winding in series and noting the current strength, then removing the ammeter from the circuit without changing any other adjustment and measuring the difference of potential at the terminals of resistance. If the supply current has been maintained unchanged, the resistance of the measured circuit will be given with sufficient accuracy by dividing the difference of potential by the current.

A 25-kw. 110-volt compound-wound generator operated in parallel with a 50-kw. compound-wound machine gradually loses its voltage after being put in circuit, and when all of its field rheostat has been cut out, the larger machine has to keep the voltage up. When the small machine is thrown out after having run with the large one for several hours, the voltage immediately runs up to between 140 and 150 volts, and the field rheostat of the 50-kw. machine has to be manipulated to bring it back to the normal value. What is the trouble? J. M. W.

It is impossible to analyze a trouble of this sort accurately from a distance, but the data given indicate that the series coils of the small machine are connected up backwards and that when its field rheostat is all cut out, increasing the field strength of the larger machine results in its driving the smaller one as a motor.

What will be the voltage between the negative terminal of a constant-current arc light machine and the nearest lamp on the circuit, the lamps requiring 75 volts each? (2) What are multipliers for; do they indicate the voltage at any place in the line or across the brushes? W. W.

This depends on the size of the line wire, its length and the current in the circuit. The voltage referred to is simply the drop in the line wire between the terminal and the nearest lamp, and is equal to the resistance of the wire multiplied by the current that it carries. (2) If you mean the resistance that is used in series with a voltmeter in order to alter its range, this does not "indicate" anything. It is put in series with the voltmeter to enable the latter to be used on circuits of higher voltage than it could be used on directly.

A compound-wound dynamo when operated in parallel with two shunt-wound machines of the same rated capacity does not take any of the load. How can this be remedied? (2) Can the compound-wound machine be used in parallel with the shunt-wound machines to maintain constant potential on the circuit without adjusting the field rheostats? C. L. B.

By cutting out more of the shunt-field resistance of the compound-wound machine, or else increasing the resistance in the field circuits of the other machines. If neither of these is practicable, then the speed of the compound-wound machine will have to be slightly increased. (2) Yes; but the machines will not divide the load proportionately throughout their range. They should be adjusted so as to divide the load equally when it is of the magnitude most frequently carried.

What is the expansion co-efficient for the common metals of commerce when subjected to heat? (2) What is meant by the mechanical equivalent of heat being 778 foot-pounds? (3) What is the specific heat of a substance? E. W. K.

There are three co-efficients of expansion —linear, surface and cubic. These co-efficients respectively for cast-iron are: 0.00000617, 0.00001234 and 0.0000185; for wrought iron, 0.00000686, 0.00001372 and 0.00002058; for untempered steel, 0.000006, 0.00001198 and 0.00001798; for copper, 0.00000955, 0.0000191 and 0.00002864. (2) For each heat unit produced by mechanical work, 778 foot-pounds of that work are required. (3) The ratio of the heat units required to raise the temperature of the substance 1°, to that required to raise the temperature of a pound of water from 39.1° to 40.1° Fahr. For example, the heat required to raise the temperature of a pound of water from 39.1° to 40.1° Fahr. is 1 B.T.U.; dividing 1, therefore, by the heat units required to raise the temperature of a pound of iron one degree will give the specific heat of that iron.

MAKING AND LAYING A 500-MILE CABLE.

This year a contract was taken by the Safety Insulated Wire & Cable Company, in competition with European manufacturers, to make and lay a cable under specifications from the Mexican Government Telegraph Department, to connect the ports of Vera Cruz, Frontera, and Campeche in the Gulf of Mexico. The contract length of this cable was 472 nautical miles, or 544 statute miles. The cable has recently been made and laid, and since it is the first cable made in America for foreign owners, and also the first cable of any considerable length laid by an American cable manufacturing company, an account of its manufacture, shipment and delivery on the selected sea-bottom may be of interest.

The engineering specifications for the manufacture of the cable were drawn by Mr. Ira W. Henry, vice-president of the Safety Company, and the cable was manufactured at the Safety Company's works at Bayonne, on the water front of New York Bay.

Inasmuch as the details of size and construction differ considerably in different cables, according to the depth of ocean, topographical conditions, and the views of the engineers who draw up the specifications, the particular process of manufacture to be described applies in detail only to the Mexican Gulf Cable here considered. The electric conductor of the cable consists of a strand of nine tinned copper wires—eight wires of the same size spiralled about a larger central wire. A stranded conductor is not only more flexible than a solid conductor, but is also less liable to accidental breakage.

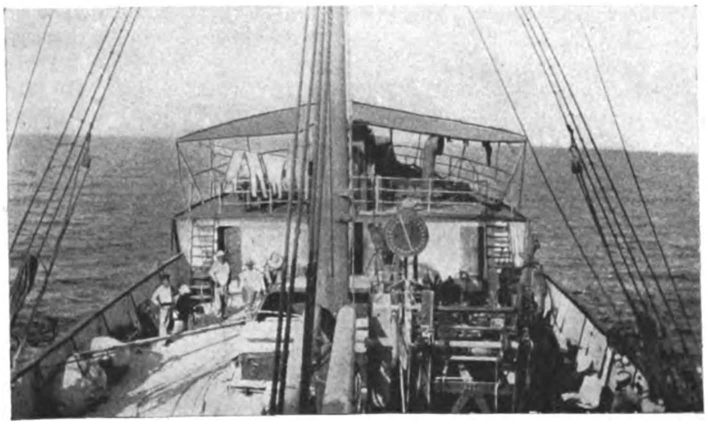


FIG. 1.—FORWARD DECK AND PAYING-OUT GEAR, STEAMER "YDUN."

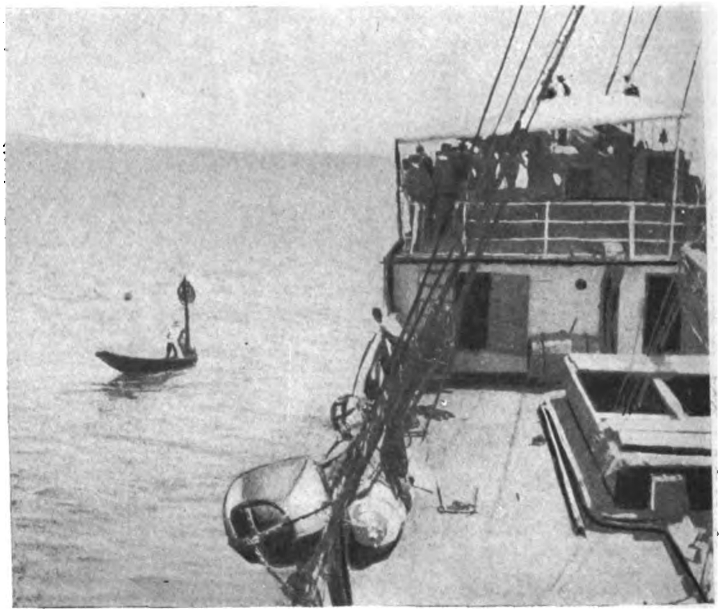


FIG. 2.—SETTING MARKING-BUOY AT SEA.

The stranded conductor is given its first coating of insulation by being passed in mile lengths through a machine which lays on a thin seamless coating of pure rubber gum. The strand then passes through a second machine, in which it receives a thicker seamless coating of a vulcanizable compound containing over 40 per cent of rubber. This completes the insulating portion of the covering. The outer layer of rubber compound is vulcanized by being put in a closed chamber into which steam is turned for a suitable time. This rubber covering will stand knotting, scraping and rubbing remarkably well. It is mechanically stronger in these respects than gutta-percha. Whereas gutta-percha lasts indefinitely under water, but oxydizes slowly in air, rubber vulcanized in this manner will last indefinitely either in water or in air. Moreover, it is not injured or affected by exposure to relatively high temperatures, such as the temperature of boiling water.

After the rubber covering is vulcanized, it is taped and the cable is joined together in 5-mile lengths, the joints in the conductor being covered, of course, by a compound that securely joins the ends of the rubber covering. The 5-mile lengths are then tested for imperfections in the rubber insulation by means of 5000 volts of alternating e. m. f., this potential being applied for five minutes. It is next tested for capacity and conductor resistance, and after passing all the tests, goes to the armoring machine.

The armoring machine consists, broadly, of a series of discs mounted on hollow horizontal spindles and a series of troughs, one trough being located between each pair of neighboring discs. The spindles of the discs are in line with each other, so that the cable to be armored can pass through the entire series without being subjected to abrupt bends. On each disc are mounted several bobbins of the material to be applied to the cable. Thus, the first two discs in the series carry bobbins of jute; the next disc carries sixteen bobbins of galvanized steel wire, each strand of wire being covered with a compound and taped, and the next two discs carry bobbins of jute. The troughs between the discs contain a compound of a tarry character, through which the cable is drawn during the process of armoring. The first two discs revolve in opposite directions, so that as the cable passes through them it receives two layers of jute laid on in spirals of opposite pitch. Passing through the third disc, it receivers the armoring of galvanized steel wires, and the last two discs apply two more coatings of jute wrapped in opposite directions. As already intimated, each layer of the coverings applied to the cable is coated with the tarry compound in the trough located next to the disc which applies the covering. After the last two servings of jute, the cable is given a coating of preservative compound and a final coating of talcum, the function of the latter coating being to render the surface non-adhesive. Thus, the cable conductor with its covering of vulcanized rubber enters one end of the armoring machine in this condition and comes out at the other end finished armored cable, ready to be coiled away in steel tanks, where it can be tested under water.

The dielectric strength of the insulation is tested by the application of 1,000 volts of direct-current pressure, and the usual insulation, capacity and conductor-resistance tests are applied by battery. As each of the 16 armor wires will withstand about 1,000 pounds pull before breaking, the breaking stress of the cable is in the neighborhood of eight tons.

The cable made as just described is deep-sea cable, for laying in relatively deep water. Near the shore, and in shallower water, a heavier cable is used, of a "shore-end" type, which is made by passing deep-sea cable through another armoring machine, where it receives an additional sheathing of 18 galvanized steel wires, and external servings of jute and compound. The breaking stress of the cable is thus raised to about 20 tons. The shore-end cable is about 1 2-3 inches in diameter and weighs 6½ long tons to the nautical mile, in air. The deep-sea cable has a diameter of about 1.11 inches, and weighs 2½ long tons per nautical mile.

As the Safety Company did not possess a cable-ship of its own with which to lay the cable, it was necessary to charter a vessel for this purpose. There was considerable difficulty in securing a suitable vessel. The total weight of the cable was 1,500 short tons, and its total coiling space was no less than 28,000 cubic feet. The cargo space available on an ordinary steamer of 1,500 tons carrying capacity is commonly 80,000 cubic feet, or nearly three times more than the cable would occupy. But in the ordinary cargo steamer the space is arranged in such a manner that but little of it is available for stowing cable. In order to be paid out safely, the cable must be coiled away in large tanks, nearly the breadth of the ship in diameter, and these must be open cylinders from the top to the bottom; whereas the ordinary ship has "between-decks" that are continuous fore and aft, except for relatively small hatches. Enlarging these hatches sufficiently to allow the tanks to be erected would involve cutting steel beams, stringers, diagonals and hatch combings, and subsequently restoring them, both operations being extremely expensive. Without the deck cutting it would probably require a 10,000-ton ship to receive the 1,500 tons of cable. The vessel finally secured for use as a cable ship was the *Ydun*, the construction of which ship was well adapted to the purpose. The vessel had no 'tween deck, so that below her main deck she was practically a huge steel box. Consequently, in order to make room for the four cable tanks required, it was only necessary to remove some vertical steel stanchions and compensate for the absence of their strength by some trusses and tie rods close to the under side of the deck. The steamer is 240 feet long, with a beam of 25 feet, and a carrying capacity of 2,000 tons.

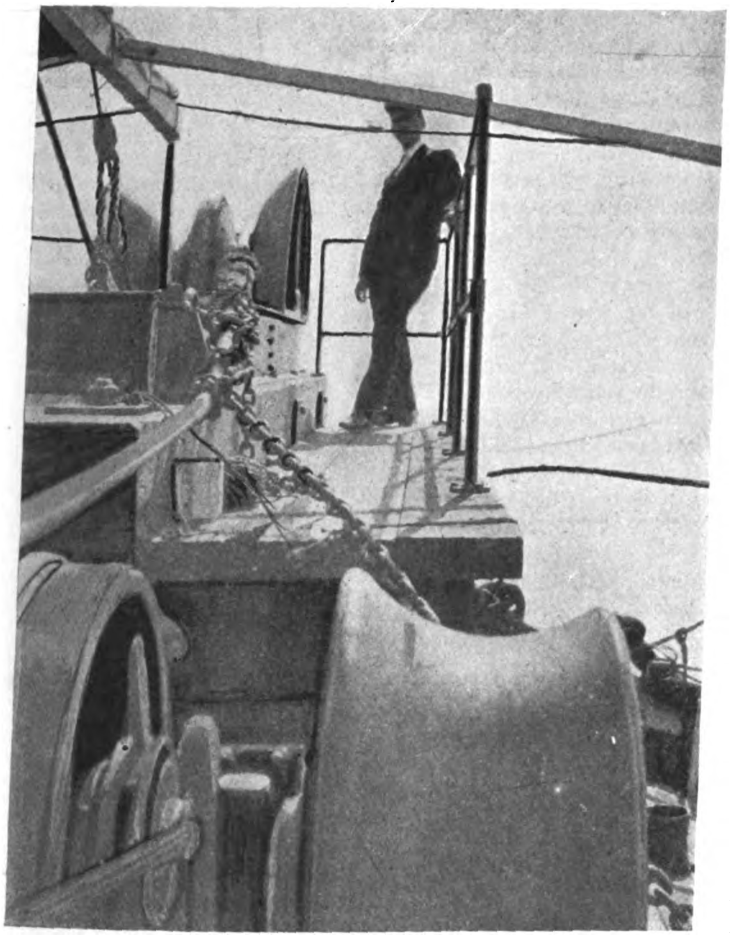


FIG. 3.—BOW SHEAVES WITH CABLE IN STOPPERS.

The cable tanks were made of wooden crib cylinders. In each tank the crib was formed of a circular row of 12-in. by 8-in. vertical timbers, 2½ ft. apart, at their upper ends. They were supported laterally by ties between them, and by other ties to the sides of the ship. They were also girdled by steel ropes, drawn tight by wedges, driven and nailed. In the center of each tank a conical frame of timber was erected. In addition to the tanks, eight extra cabins had to be built below the bridge to accommodate the cable-laying staff, and a testing room had also to be built. On deck the large cable-winch and gear for picking up and paying out cable was erected. This carries a six-foot steel drum around which the cable passes either into or out of the ship. It has a double horizontal engine to drive it, when picking up at either of two speeds; while a brake is attached for use in paying out. This cable gear occupied 17 ft. by 11 ft. of deck space. It was built to specifications by the Lidgerwood Manufacturing Company, and was the largest and strongest that has yet been built in America. Besides the gear, large bow sheaves had to be mounted over the stem, a smaller pair of sheaves at the stern, a dynamometer to indicate the tension on the cable, and various guide sheaves to lead to and from the various tanks. This alteration and equipment was carried out at the Robins' Dry Docks in Brooklyn, N. Y.

The electrical equipment of the vessel consisted of a small direct-connected engine and dynamo for incandescent lighting, 400 cells of battery, two D'Arsonval marine reflecting galvanometers, rheostats, Wheatstone bridges, portable testing sets, and a complete Morse signaling outfit. Nearly all of the electrical testing instruments were furnished by Messrs. Leeds & Co., of Philadelphia.

The *Ydun* was handed over to the Safety Company under charter for the reception of cable in her tanks at Brooklyn, on August 19, and the coiling of the cables from lighters into two of the tanks commenced forthwith. All the cable was coiled on board the ship by September 2, and the vessel left Brooklyn with the cable, cable staff and crew, on September 3, bound for Vera Cruz, which port was reached on the 13th. Here the ship was joined by Mr. Henry, of the Safety Company, accompanied by Messrs. A. Parra, Inspector General of Mexican Telegraphs, and Captain D. Almedo, engineer, with two assistants, who attended the laying of the cable on behalf of Senor Camile A. Gonzales, the Director General of the Mexican Government Telegraph Department.

The cable house for receiving the cable was landed in sections, and erected in the adjoining bay north of Vera Cruz harbor, well above high-water mark, and about two miles from the town. Arrangements were made to secure a lighter and steam launch to land the end on the beach. Two miles of shore-end cable were coiled in the lighter, and this was then towed by the launch around to the north bay. The lighter anchored outside the surf in about four feet of water, and with the aid of men, boats and mules, the end of the cable was hauled ashore and connected to the terminal board in the cable house. The steam launch then towed the lighter slowly seaward along the selected course, and the lighter paid out the two miles of cable as she went; the sea end was buoyed in 10 fathoms of water, at a position where the ship could readily come in and reach it.

On the day following the *Ydun* left Vera Cruz harbor and came around to the buoy over the sea-end of the north bay length of cable, which was soon picked up. After speaking and testing through the cable to the cable house, the deep-sea cable in one of the tanks was spliced on, and the ship commenced laying the cable towards Frontera, steering during the night by the bearings of the lighthouses in the neighborhood. After steaming steadily for two days and nights at an average speed of nearly four knots, the ship arrived off Frontera, and came into water sufficiently shallow to require a change from deep-sea to shore-end cable. Here the cable was cut and buoyed, about nine miles from Frontera beach, and the ship steamed at full speed to Frontera, and anchored near the mouth of the River Tabasco.

Here the Frontera cable house was landed and speedily erected on a suitable site near the beach and lighthouse. With a steam launch and lighters, two short diverging shore-ends were laid out from the cable house, and their sea-ends buoyed. The ship then picked up the western sea-end, spliced on heavy cable to it, and paid out to the Vera Cruz end buoy, nine miles out to sea. Reaching this buoy, the Vera Cruz end was picked up and found to be in good electrical condition. The cable paid out from the tank was then cut and spliced on to the Vera Cruz end, thus making the final splice and completing communication between Vera Cruz and Frontera, within thirteen days after first reaching Vera Cruz. The final tests of the cable, 234 nautical miles in length, were completed the same night from Frontera cable house.

After completing the shore-end of the Campeche section, by laying it out to sea for a distance of 8 miles from Frontera, the *Ydun* steamed directly to Campeche, in order to lay the cable from the port back towards Frontera and to make the final splice at the position of the shore-end buoy. A terrific storm delayed this work, which was already difficult enough on account of the shallowness of the Campeche harbor and the fact that large numbers of boats anchor there. The work was completed, however, on October 11, just 38 days after the ship had left New York Bay.

The entire engineering charge of the cable-laying expedition was given to Dr. A. E. Kennelly, Professor of Electrical Engineering at Harvard University, who also served as inspector for the Mexican Government during the manufacture of the cable. With him were associated on the ship the Safety Company's engineering staff, consisting of Mr. G. M. Haskell, chief electrician; Mr. William H. Rodier, cable superintendent; Messrs. R. O. Smith and Thomas Bayne, assistant electricians, and Messrs. John Lind and Julius Bernstein, assistant engineers.

TEST OF THE CLARE STORAGE BATTERY.

An interesting test was recently performed at Quincy, Mass., by Dr. Louis Bell, Prof. Louis Duncan, and J. H. Hampton on the new Clare battery made by the Consolidated Storage Batteries Company, of New Jersey. The tests were made in connection with a 25-ft. electric launch of the standard type, furnished by the Electric Launch Company, of Bayonne, N. J. The battery, weighing 1,870 lbs., drove the launch 41.74 miles at the rate of 5.59 miles per hour.

In order to compare the Clare cells with one of the standard cells on the market, the launch was tested with the battery originally furnished with it. This battery consisted of 44 nine-plate cells, weighing in the aggregate 1,320 lbs., and drove the launch 24.8 miles at an average rate of 4.88 miles per hour. When the launch finished her run the battery was practically "dry" and the cells were delivering current at 1.63 volts each.

The Clare battery was substituted and tested under the same conditions of weather and load. The battery consisted of 44 cells, weighing 1,870 lbs., an addition of 550 lbs. to the load, which was responsible for a corresponding increase of the wetted surface. The launch covered 41.74 miles in 7 hours and 27 minutes, an average of 5.59 miles per hour; and when the run was over the voltage of each cell was 1.75 volts. Fig. 1 gives the various data recorded in curves. The result of the test showed that the weight per mile of endurance was about 44 lbs. for the Clare cell, as against 54 lbs. for the other battery. The manufacturers claim that the weight of the Clare cell per ampere-hour is less than half that of the best lead grid cell now on the market.

The electric launch on which these trials were made was 23 ft. and 5 ft 8 in. beam on the water line, with about 3 ft draft. She was fitted with a 3-h.p. standard launch motor, driving a 3-bladed bronze screw, of 7 inches radius and composite pitch, at about 700 r.p.m. When the launch was purchased for the tests she had made less than 100 miles in all with the battery with which she was equipped, and prior to the first trial the battery was carefully worked up to good condition electrically, and was in excellent general order. The launch had rather coarse lines, which accounts for the moderate general speed in both trials. The Clare battery was tested after 13 regular discharges, subsequent to the forming run.

The weather in the two trials was favorable, with fairly smooth sea and with conditions of wind and tide closely uniform. In each test the boat was driven twice through severe adverse tides. The fundamental purpose of the experiments was to demonstrate that the Clare cell with a construction especially planned to avoid deterioration through service, could hold its own in weight efficiency as compared with the lightest standard forms of lead grid battery. Hence the same boat motor, screw and general equipment was retained intact in both trials, the battery alone being charged.

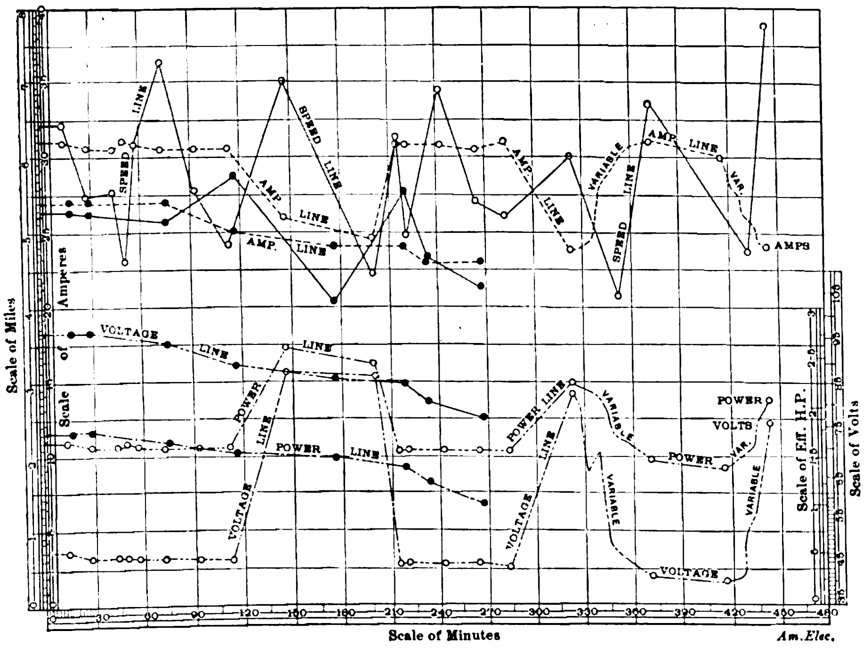


FIG. I.—CURVES FROM CLARE BATTERY TEST.

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LINE WIRE TRANSPOSITION.

The method of transposing telephone and other line wires in general use consists at present of cutting in on the cross-arm or pole; and when it becomes necessary to renew cross-arms or poles, the transposition is cut out and then replaced. It often occurs that linemen working on poles step on a transposition, thereby causing a short circuit on the line which is difficult to locate. J. O'Brien and J. Mattmore, of West Brighton, Staten Island, N. Y., have brought out a system shown diagrammatically in Fig. 1 whereby the transposition is cut in at the pole, and then moved to any desired point between the poles. The material used for a transposition consists merely of three full connector sleeves and a short piece of wire; whereas ordinarily a transposition requires two full and six half sleeves, two transposition pins, two insulators and about six feet of wire. There is by this method no interference in renewing cross-arms and poles, nor in pulling up slack wires, and danger of short-circuiting the line at the transposition is avoided.

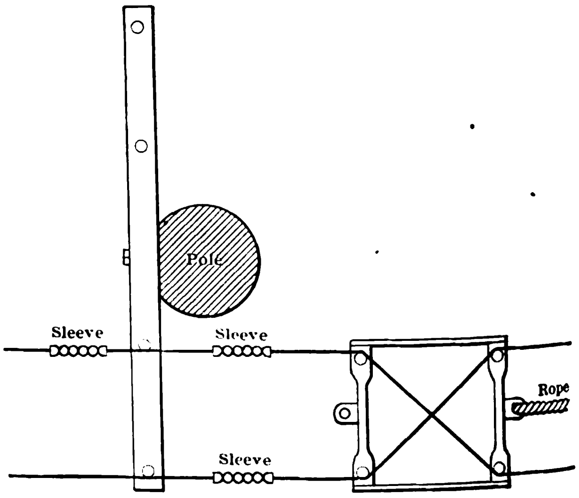


FIG. I.—TRANSPOSITION OF LINE WIRES.

New Apparatus and Appliances

SIMS EXHAUST HEAD.

Fig. 1 herewith shows an improved Sims exhaust head which is manufactured by the Sims Company, of Erie, Pa. The method of operation is as follows: In the lower section of the head is a deflector, with four or more ports (according to the size of the head) shown at *A A*. These ports being circular give centrifugal motion to the steam, throwing it against the ribs *B*, where the moisture and grease is intercepted. A part of the exhaust steam passes out at the top of the deflector into a cone shaped deflector with considerable force, as indicated by arrows, driving the water from the ribs into the well below, from which it is piped off.

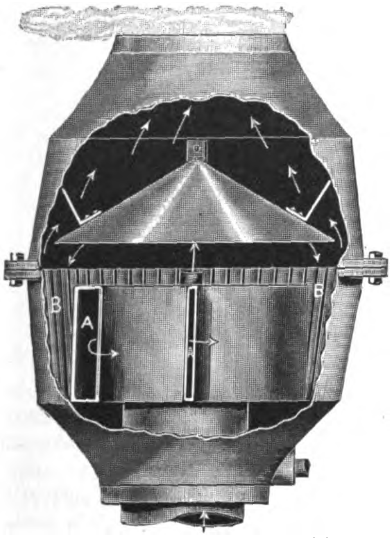


FIG. 1.—SIMS EXHAUST HEAD.

A NEW HOOK-SWITCH.

In Figs. 2 and 3 are shown views of a new hook-switch recently placed on the market by the Stromberg-Carlson Telephone Manufacturing Company, of Chicago. The hook is of the long lever type and mounted on a heavy brass frame fastened with bolt and nut. The hook lever forms no part of the circuit, but all contacts are made by the springs mounted upon the lug on the side of the frame, as shown. The downward movement of the hook causes a hard-rubber insulated pin, attached to the lever, to be drawn in between the springs, thus disengaging the springs and breaking contact as shown in Fig. 3, and making contact when the hook is released as in Fig. 2. A stop is provided at the lower edge of the frame to prevent the downward movement of the lever, below the proper point. The springs are made of German silver of good length, and all contacts are pure platinum; pure hard rubber strips are used to insulate the springs from each other and the frame. At the top of the lug, upon which the springs are mounted, is fastened a strip of hard fibre with the front edge slotted, through which the wires are brought down to the springs, thus keeping them separated and reducing the chances of short-circuiting to a minimum.

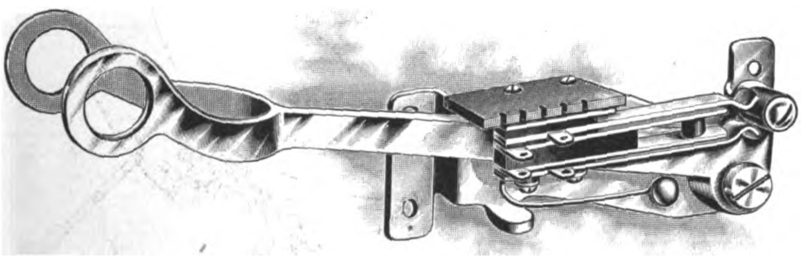


FIG. 2.—STROMBERG-CARLSON HOOK SWITCH.

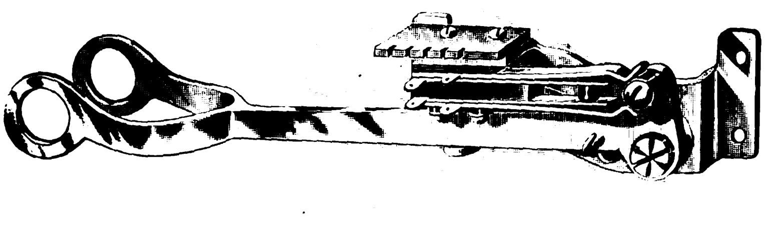


FIG. 3.—STROMBERG-CARLSON HOOK SWITCH.

IMPROVED DRAFTING INSTRUMENT.

The Universal Drafting Machine Company, of Cleveland, Ohio, has placed upon the market the instrument shown by Fig. 4 and known as the "Rapid Sketching Device," which is designed to lessen the manual work of the draftsman to a considerable degree. The device consists of a scale joined to a protractor which is anchored to the upper left-hand corner of the board by means of an arm made up of two pivoted parallelograms. The scale has a free motion of 90° between two stops, and it comes against either one or the other, depending upon whether a horizontal line or a vertical line is desired. These two stops are fastened to a protractor and may be turned to any angle with the horizontal or vertical, thus permitting the scale to come against a stop at the desired angle and also at right angles to it. The lower part of the protractor always lies in the same direction, no matter where it is moved about the board, and hence when the protractor is once set at any desired angle the scale will give parallel lines anywhere on the drawing. This is accomplished by the two parallelograms which act similarly to a parallel ruler. The protractor may be clamped at any angle by means of a thumb screw, and a spring stop is provided for the 0°, 30°, 45°, 60° and 90° angles. The stop is operated by merely raising it and allowing it to drop into the hole for the angle desired. The scale, which may be of either the triangular or flat type, is fastened to the head by a chuck and may be readily removed, replaced or turned around so as to bring the desired edge into use, since the scale moves freely between the two stops, with spring stops at 30°, 45° and 60°, these being the angles most frequently used, it is thus possible for the manipulator to set his scale at these positions quickly without referring to the protractor to be sure of their accu-

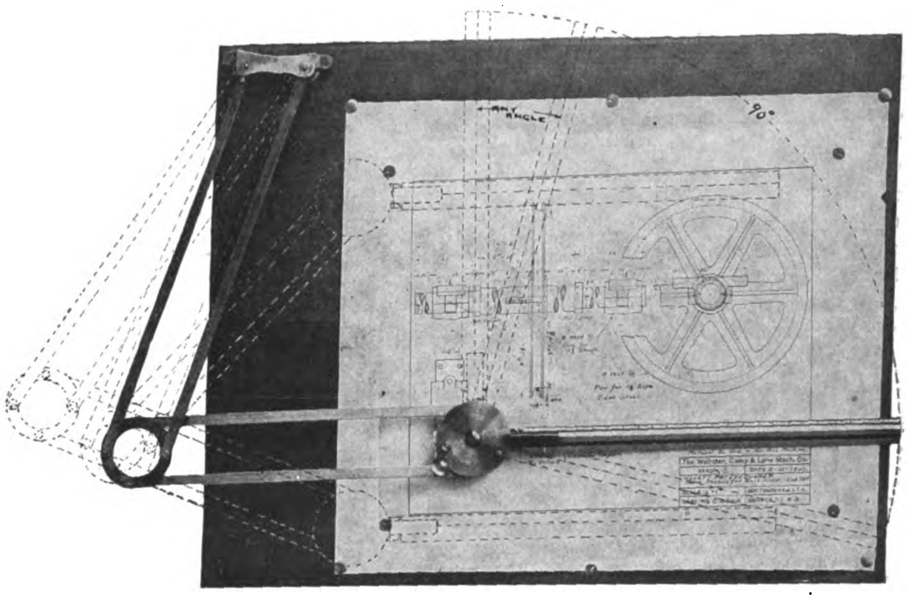


FIG. 4.—RAPID SKETCHING DEVICE.

racy. In changing the setting of the protractor, all of the stops are simultaneously revolved, and the common relations of lines may be readily established on the new base. The flat horizontal placing of the rods in the arm gives rigidity where necessary, but also allows a desirable flexibility in a direction perpendicular to the plane of the paper. The scale will, as a consequence, lie flat on the paper, but may be raised slightly in moving from place to place, to avoid the rubbing of fresh ink lines. The feature of the machine which is of greatest importance to its perfect working order is the tightness of the joints in the arms. After trying a number of kinds, the makers have finally adopted a hardened ground joint, which, on account of the slight pressure and speed with which it is used, will last indefinitely. The pin for the stops is made conical to compensate for wear. All parts are finished in nickel except the rods, which are coppered and oxidized. The boards are regularly furnished 19 x 23 inches in size to accommodate sketches 18 x 20 inches, but by special order may be had in any size.

IMPROVED "HYLO" LAMP.

The Phelps Company, of Detroit, Mich., has brought out an improved "Hylo" lamp in which the objection to the looseness of the lamp in the socket owing to the spring lamp base, is overcome. It will be recalled from descriptions of this lamp published in these columns, that in one position the full candle-power filament is in circuit; and that in another position, the low candle-power filament is switched in, and its companion switched out of circuit. The improved lamp is shown by Fig. 5. In this form the lamp has a firm seat in the socket, and a cord carries the connections for the two filaments to a small push-button switch made in finished nickel and hard rubber. At the base of the push is the switch which throws in the full candle-power filament, and at the side is a corresponding switch which cuts out the full candle-power filament and throws in the low candle-power filament. The push switch is so connected up that the operation of each switch cuts out the other with a sharp snap. The whole arrangement is of fire-proof construction carefully designed to meet the underwriters' requirements.

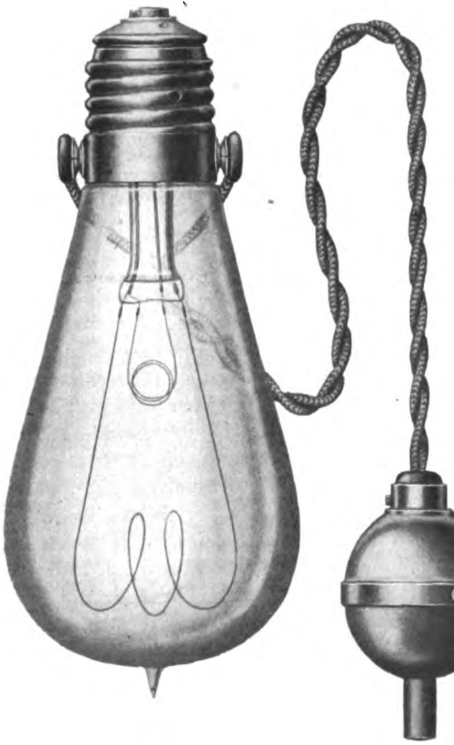


FIG. 5.—'HYLO" LAMP AND SWITCH.

NEW "BALL" ENGINE GOVERNOR.

The accompanying illustration, Fig. 6, shows a new form of automatic cut-off engine governor just adopted by the Ball Engine Company, of Erie, Pa. The eccentric is mounted on a pin and thrown to and fro by the weight or the spring, as the case may be, the oscillation being in such direction as to vary the throw of the eccentric and also the lead of its major axis with respect to the crank. The parts are claimed to be practically in gravity balance, and as the illustration shows, they have been reduced to the fewest number with which a governor of the shaft type can be constructed. Speed adjustment is accomplished by varying the tension of the spring and by varying the leverage of the weight and spring over the frictional resistance of the eccentric-block pin and strap. The tension of the spring is adjusted by means of the set-screw shown on the lowermost spoke in the engraving. If the engine shows a tendency to race, the link connecting the weight to the eccentric arm should be set farther out toward the end of the arm; on the other hand, if the engine does not govern closely enough, the end of the link should be moved in toward the center. The governor combines both the so-called inertia and centrifugal actions, and it is claimed that the relation between the two is so carefully fixed that the governor is not only powerful but is quick acting without being objectionably sensitive and delicate.

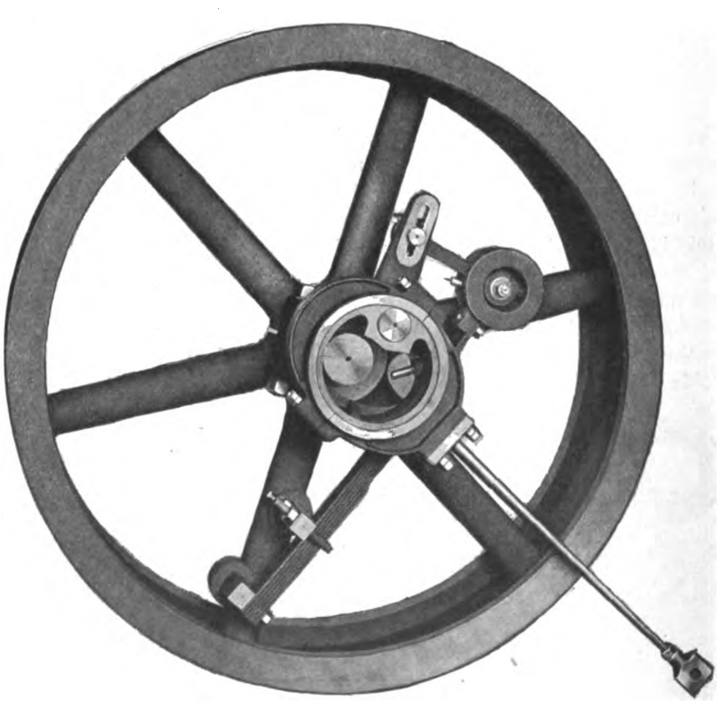


FIG. 6.—NEW BALL ENGINE GOVERNOR.

STERRETT OIL PUMP.

Fig. 7 shows an oil pump made by the Sterrett Pump Company, of St. Paul, Minn., which is provided with valves of such construction as to permit heavy oils to pass through them. In the bottom of the tube is a ball valve consisting of a seat screwed into the end of the tube and having an opening wherein is seated a ball. Vertical arms permit the ball to rise and fall without leaving the vicinity of the seat. The lower end of the valve stem consists of a plunger which has a cylindrical portion to snugly fit within the tube, an annular groove in the periphery of this portion fills with oil and serves to make a tight-working joint, the vertical portion acting merely as a guide in keeping the valve in position. The stem carries at its end a tapered block, which rests within a seat of the same taper, being also tapered on the bottom so as to form less resistance to the oil as the valve descends. The top of the tube is flared to form a head, to which a cap is engaged by means of threads, and forms a guide for the

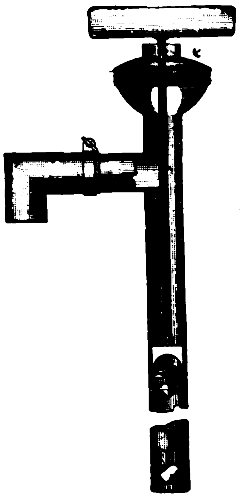


FIG. 7.—STERRETT OIL PUMP.

stem. Within this cover and surrounding the stem is a chamber composed of an annular wall and fitted with a cap; and within this chamber is a metal washer and other suitable packing material. The pump is made entirely of brass.

INSULATORS FOR HIGH-TENSION TRANSMISSION.

It is quite a common matter to transmit energy at a very high potential over long distances and it is, therefore, of the utmost importance that an efficient insulator should be forthcoming. F. M. Locke, of Victor, N. Y., has recently brought out a type of high-voltage insulator shown by Fig. 9 herewith. The insulator is made of a special mixture of clay and is designed to carry a working potential of 80,000 volts. It is 14 ins. across the hood, 11½ ins. high and weighs 18 lbs. An idea of its size may be had from the illustration, which shows to the left a standard glass telegraph insulator. A slightly higher insulator having the same size of hood, but provided with three petticoats, was tested for 160,000 volts, and a working potential of 100,000 volts. The same manufacturer also makes the insulator shown by Fig. 8, which has a raised rim around its outer edge. This rim has a small spout in it, so that instead of water being allowed to drop from any part of the circumference it is carried away in one stream by means of the spout. When the insulator is subjected to no electrical pressure the water flows off in the ordinary manner, but when 40,000 volts are applied the stream immediately becomes split up into very minute drops and as a result the end portions of the insulator are always dry. This type of insulator is used on many of the high-tension long-distance transmission lines in the West.

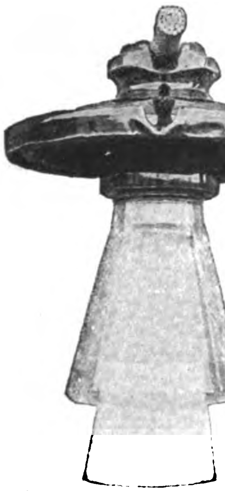


FIG. 8.—HIGH-TENSION INSULATOR.

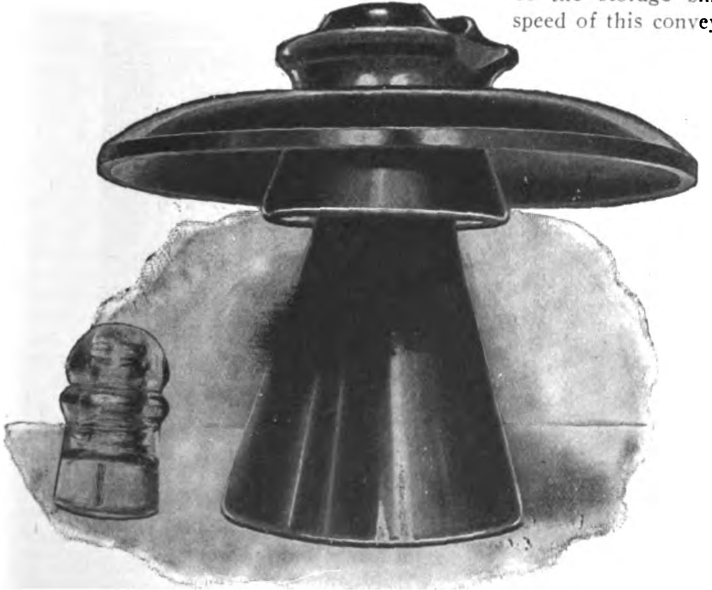


FIG. 9.—HIGH-VOLTAGE TRANSMISSION INSULATOR.

FUEL FEEDER AND REGULATOR.

The C. O. Bartlett & Snow Company, of Cleveland, Ohio, is introducing a system for burning soft coal without the production of smoke. In designing the system, the inventors held that three principles must be considered to secure absolutely perfect combustion. First, the coal must be of uniform size; second, the coal must contain a constant amount of moisture; and third, the powdered coal must be burnt in suspension. Under the sytem perfected by this company, the cheapest kind of slack coal is used. It is first treated in a dryer designed for the purpose until the amount of moisture present is about 2 per cent. It is then carried to a pulverizer on a conveyor and ground as fine as 80 mesh, whence it is conveyed to the feeder outfit which constitutes the novel feature of the system. The method of operation may be seen from the accompanying engraving.

The ground coal is stored in an iron storage tank or hopper, above or near the boiler. An air pipe, *A*, is connected with the feeder spout at the furnace, and above the boiler, in the breeching or stack, a blower fan of sufficient size to furnish the necessary air for burning the coal is attached to this pipe. The coal is conveyed by a worm or spiral conveyor from the bottom of the storage bin to a spout, *B*. The speed of this conveyor controls the amount of coal used, and it can be regulated by adjusting a roller to or from the center of a friction disk on the conveyor. From the conveyor the coal is fed direct to the air spout, *A*. On the inside of this spout there is a nozzle which concentrates the air just as it strikes the coal coming down from the conveyor, thoroughly mixing the coal with the air and at the same time preventing any danger of clogging. The coal is caught by the current of air and blown along the air spout to the furnace spout. Just before entering this there is another nozzle with an opening or mouth, concave in shape, so that the dust is sprayed upward against the arch wall and in passing over the flame it is ignited and consumed. The feed spout is bricked in and well protected so that it will not burn out. The continual blast of air passing through this feeder also has a tendency to keep it cool, so there is no danger of burning. There are slides or valves at different points on the air shaft, and these can be adjusted to admit just enough air to insure perfect combustion.

For commercial use the company propose to furnish systems of conveyors to take care of the coal from the time it is dumped on the overhead coal pile until it is consumed in the furnace.

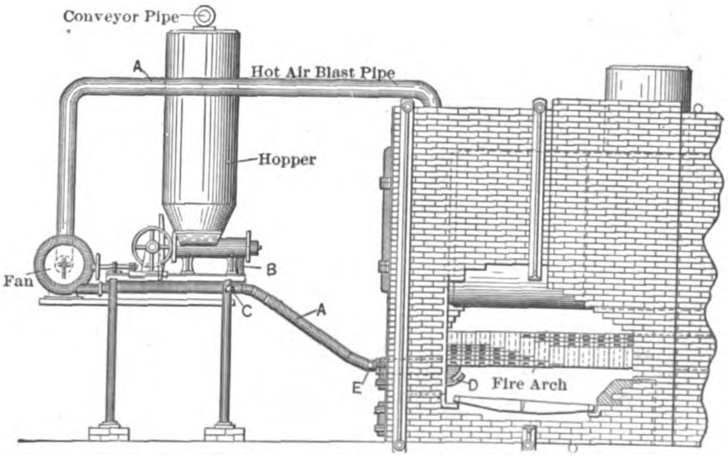


FIG. 10.—FUEL FEEDER AND REGULATOR.

IMPROVED SOCKET CONSTRUCTION.

We illustrate herewith a new improvement in socket construction which has just been put on the market by the Marshall-Sanders Company, of Boston, Mass. The improvement consists of an elastic fibre insulating lining which is said to be expansible, so that it may be readily forced into the socket shell by the fingers and as easily removed. It appears that considerable difficulty has been experienced in removing the linings from the socket cells in order to refinish the shells, while on the other hand, linings have been so loose that they easily dropped out. The lining illustrated in Fig. 11 is said to exert sufficient pressure against the shell so that it cannot be easily shaken or dropped out.

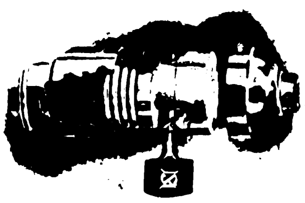


FIG. 11.—LAMP SOCKET.

PERMANENT CONDUIT AND SIGN RECEPTACLE.

An entirely new departure in conduit and sign work is being brought out by the Crouse-Hinds Electric Company, of Syracuse, N. Y. This is known as the Norbitt permanent conduit and sign receptacle, and embodies all of the enclosed contact features of the Norbitt molding receptacle. The receptacle is made in two pieces, a cap and a base, both of which are shown by Figs. 12 and 13. The base is fastened permanently to the conduit box or base of the sign with one screw, which passes through the center. The initial electrical connection to the circuit wires is made by means of two binding screws on the top surface of the base as in the molding receptacle. Two screws serve the double purpose of fastening the cap in place on the base and of completing the electrical connections. These two screws are so constructed that it is impossible for them to drop out during installation, which in overhead work is a point of considerable advantage. The base is permanently installed while the rough work is being done and cannot be affected by plasterers, decorators and other workmen, and the circuits may be tested for electrical defects before the rough work is completed.

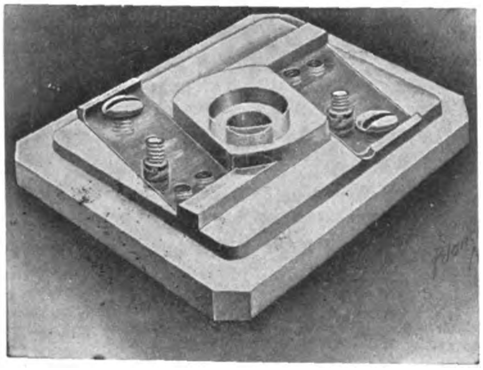


FIG. 12.—BASE.

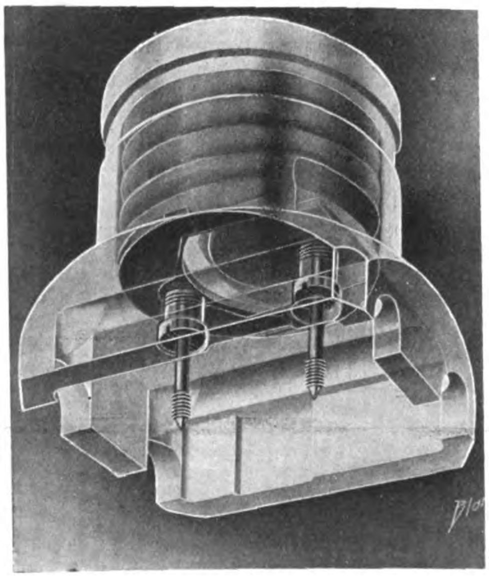


FIG. 13.—CAP.

The cap which is put on after all other work is finished, covers the base protecting all connections and makes the installation complete, safe and workmanlike. The receptacle does away with all taps, unused wires, or slack wire in the conduit or sign box, and is not a covered tap, but an actual rosette. The single center fastening screw permanently secures the base to the molding.

THE BUTLER DRILL CHUCK.

Figs. 14 and 15 herewith illustrate a new drill chuck which has been placed on the market by the Butler Chuck Company, Greenfield, Mass. This chuck differs in construction and principle from any heretofore made, and the results obtained from its use are said to be very satisfactory. Its distinctive feature is the enormous grip which is said to be obtained upon the drill or other tool it is holding. Fig. 14 shows the chuck in two sections, with the working parts exposed. It consists of an arbor sleeve, cap, plug and three jaws. The arbor and sleeve appear at the left, the cap, plug and jaws at the right in Fig. 14. The arbor or shank can be turned to any taper desired. The end of the arbor, or that portion which enters the knurled sleeve, has on its surface a right-hand thread. The center of the arbor is bored and tapped to receive the left-hand threaded plug corresponding to the thread on the surface. Around the arbor revolves the knirled sleeve to which is rigidly attached the conical cap. The sleeve and cap work together, except when assembling or dismantling the chuck. Within the conical cap are three oblique converging channels which guide and support the jaws. Above the cap, in Fig. 14, is shown the left-hand threaded plug, on the lower face of which are three horizontal converging channels, in exact relation to those in the cap and into which are placed the uuper flanges of the jaws. The jaws are wedge shape forgings, on the back and top of which are circular flanges to correspond with the channels in the cap and plug. When the chuck is assembled the plug is screwed into the arbor and the sleeve screwed firmly to the cap. Thus by revolving the body of the chuck to the right it travels up the arbor at the same time the plug travels down into the cap, forcing the jaws out with just half the revolutions usually required, also confining the travel of the body to a very short distance. The friction rests on the plug, which is of small diameter, and the grip of the hand in tightening the chuck is greatly multiplied through the differential screw.

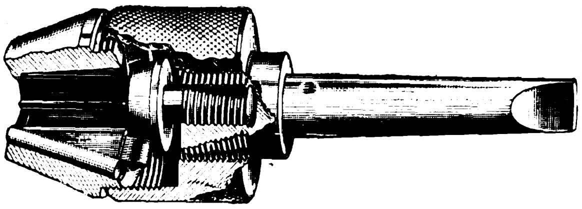
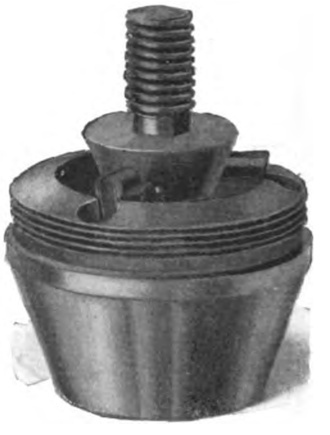


FIG. 14.—BUTLER DRILL CHUCK.



—FIG. 15.

MAXIMUM DEMAND INDICATOR.

Fig. 16 shows a new type of maximum demand indicator, which has been very largely adopted recently by English central stations. The inventor is Mr. E. B. Schattner, and the instrument is manufactured by the Schattner Electricity Meter Company, Upper Street, Islington, London. The instrument is extremely simple in construction, and consists essentially of a metallic frame pivoted at the center, and carrying at one end a cylindrical iron core entering a solenoid and at the other end a glass tube and scale. As will be seen from the engravings, one part of the glass tube is bent to the arc of a circle concentric with the pivot of the frame. The tube contains a number of steel balls, and is filled with glycerine or oil. When the current is passing the core is sucked into the solenoid,

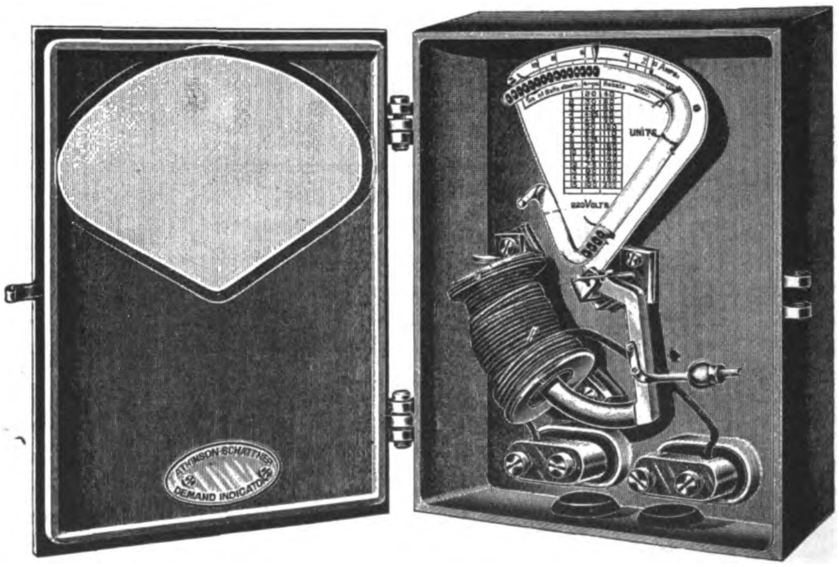


FIG. 16.—MAXIMUM DEMAND INDICATOR.

and the frame is tilted to the right of its pivot; any balls to the right of the highest point of the curved portion of the tube then slowly slide down and pass around the bend into the lower limb of the tube, where they remain. If at any time the frame is tilted by the solenoid still further to the right, one or more additional balls will be caused to descend into the tube. Consequently, when the meter is to be read, it is merely necessary to count the balls contained in this tube in order to determine the maximum current that flowed in the period since the meter was last set. The tube is filled with oil or glycerine, the vicosity of which determines the speed at which a ball passes through the curved portion of the tube. A time element is thus introduced which prevents a ball descending into the lower limb if the higher current is merely momentary. According to the vicosity of the oil chosen, this leeway may vary from less than a minute to ten or more, and the time element can be made still larger by the use of glycerine as the fluid in the tube. Changes in the temperature of the fluid merely act to change this time element, in the selection of which there is considerable latitude. The balls, which are of steel and highly polished, are of the same type as those used in bicycle bearings. The upper part of the sector carrying the tube is graduated, and in reading the sector is moved so that the end of the line of the balls remaining in the curved tubes comes below a point projecting down from the case, when the maximum amperes that had passed in the circuit can be read off on the scale. The tube is supported in the sector by three light wire clips; to reset, the tube is removed and tilted until all the balls are returned to the curved portion, when it is reclipped in the frame. The coils of the solenoid are so wound as to give as nearly as possible a uniform pull, and the range of the pull is such that one ball goes down for every quarter of an ampere in the middle of the scale and for every half ampere on the remainder of the scale. To set the scale to zero, there is an adjustable weight on an arm projecting from the pivoted frame.

LEGAL NOTE.

FAN MOTOR PATENTS.—The United States Circuit Court for the southern district of New York has decided the suit of The Diehl Manufacturing Company *vs.* The Dayton Fan & Motor Company in favor of the former company, and has issued an injunction forbidding the Dayton Company to manufacture, use or sell apparatus covered by claims 1 and 2 of patent No. 414,757, and claims 2 and 4 of patent No. 414,758, granted to Philip Diehl; claims 1, 3, 4 and 5 of patent No. 465,360, and claim 6 of patent No. 465,361, granted to Philip Diehl and Edwin H. Bennett, Jr., and claims 1 and 5 of patent No. 585,250, granted to Edwin H. Bennett, Jr., these patents being owned by The Diehl Manufacturing Company. The patents all relate to electric fans, except the last-named one, which covers a combined electric fan and electrolier.

PERSONAL.

MR. R. S. MASON has been appointed consulting electrical engineer of the Los Angeles Railway Company to prepare or pass upon all plans for electrical machinery and apparatus, and to outline the arrangement of installation.

MR. E. J. LAVENS, formerly connected with the General Incandescent Arc Light Company, on January 1 assumes full charge of the switchboard, panel board and switch departments of The Bossert Electric Construction Company, Utica, N. Y.

MR. W. F. HATCH, formerly of The Wagner-Hatch Motor Company, Chicago, has wound up the affairs of that company and accepted the vice-presidency of the Cincinnati Electric Motor Company, recently organized for the purpose of building high-grade motors and dynamos.

MR. C. E. L. BROWN, the distinguished electrical engineer of Switzerland, and in many ways the European leader in power transmission work, is the subject of the Bullock Company's calendar card for December. The card gives a good little portrait in colors and a brief but excellent biographical sketch.

MR. ROBERT L. WARNER, Boston sales manager of the Westinghouse Company, on December 9 read a paper on "Electrically-driven Shops," at the regular meeting of the New England Railroad Club, Boston. The paper was illustrated by stereopticon views showing examples of motor application to machine-shop tools.

MR. L. S. KIRKER, formerly electrical engineer of the Wheeling Steel & Iron Company, Wheeling, W. Va., has bought the plant of the Center Foundry Company, and with friends has also purchased the Pittsburgh Engine & Foundry Company and will manufacture gas engines under the Kirker patents.

MR. BEECHER OGDEN, formerly connected with the International Correspondence Schools, of Scranton, Pa., and more lately with the American School of Correspondence, Boston, has been appointed advertising manager of The H. W. Johns-Manville Company, with headquarters at 100 William Street, New York.

MR. B. E. WATERS, who for twenty years held responsible positions with the American Bell Telephone Company, has been appointed general manager of The Eastern Automatic Telephone Company, Boston. Mr. Waters is well and favorably known in telephone circles, having been manager of the Brockton Exchange, of the Southern Massachusetts Telephone Company and later general manager of that company.

MR. RICHARD L. BINDER, who has for several years been manager of the engineering department of Vallee Brothers Electrical Company, Philadelphia, recently severed his connection with that company and has joined interests with Mr. W. H. G. Kirkpatrick under the style of The K. & B. Company. The new company will manufacture yellow pine cross-arms, oak and locust insulating pins, molding and ceiling blocks, and will also deal in switchboards, panel boards, motors, dynamos, etc.

MR. GEORGE W. RISTINE, of Chicago, has been appointed manager of the St. Louis Exposition's Transportation Department, and will take charge of all transportation business within the province of the Committee on Transportation. The Department of Transportation is distinct from the Department of Transportation Exhibits, which has been organized with Willard A. Smith as chief. Mr. Ristine will have charge of matters relating to rates, operation of tracks, and all business with transportation companies outside of exhibits.

DR. FRANZ MEYER, formerly chief chemist and managing technical director of the Actien-Gesellschaft fuer Zink-Industrie, Oberhausen-Rhineland, Germany, and more lately manager of the Somerset Chemical Company, Bound Brook, N. J., has opened an office at 68 Broad Street, New York, as consulting metallurgical and chemical engineer. Dr. Meyer will also make a specialty of negotiating the sale of inventions and patents relating to the metallurgical and chemical industries both in this country and abroad.

HON. CHARLES ALGERNON PARSONS, F. R. S., was recently awarded, by the British Royal Society, its Rumford medal "for the successful application of his invention of the steam turbine to industrial purposes, and in navigation." Mr. Parsons is a brother of the Earl of Rosse and a son of the builder of the famous Birr telescope. When Mr. Parsons built the *Turbinia,* in 1896, she was the first vessel to be propelled by the steam turbine. The British destroyer *Velox* is turbine-driven, and she has the distinction of being the fastest vessel in the world.

MR. JAMES M. DODGE, who was last month elected president of the American Society of Mechanical Engineers, is one of the best known manufacturing engineers in this country. He served his apprenticeship with John Roach, the famous ship builder, in New York, and at Chester. He then became connected with the Ewart Manufacturing Company, of Chicago, builders of link-belt machinery. Since that time Mr. Dodge has been very prominent in that branch of manufacturing. He is now president of the Link-Belt Machinery Company, of Nicetown, Philadelphia; of the Dodge Coal Storage Company, and of the Dodge Stair-Lift Company. He is one of the managers of the Franklin Institute, of Philadelphia, and a director in several manufacturing establishments. He has taken out over one hundred patents, principally on conveying machinery. Mr. Dodge has not been himself particularly active in the electrical field, but he is an enthusiastic convert to motor driving and his shops at Nicetown contain a model installation of electrically driven tools, while he takes a keen and most intelligent interest in electrical development. His son, Mr. Kern Dodge, is a member of the American Institute of Electrical Engineers, and is already widely known for his work in connection with electrical power distribution for tools and factories generally.

TRADE PUBLICATIONS.

HENKEL INCANDESCENT LAMP. F. M. Henkel, Cincinnati, Ohio.—A folder announcing the manufacture of a semi-metallic filament lamp in the usual candle-powers and voltages.

SWITCHBOARD INSTRUMENTS. S. E. I. Company, Syracuse, N. Y.—A folder of pocket size containing a concise presentation of the special features of S. E. I. voltmeters and ammeters for switchboard service, together with a price list of this class of instruments.

SOME FACTS ABOUT THE SPERRY BATTERY. National Battery Company, Buffalo, N. Y. —A pocket-size pamphlet pointing out in detail the features and merits of the Sperry storage battery, designed for automobile service. The pamphlet also contains some useful information on the subject of automobile batteries in general.

COMMUTATOR TRUING DEVICE. The Fort Wayne Electric Works, Fort Wayne, Ind.—This is bulletin No. 1,038, superseding bulletin No. 1,010, and containing an illustrated description of the B. & B. commutator truing device, which may be applied directly to the commutator of a machine without removing the armature from its bearings.

ST. LOUIS EXPOSITION. Robert Allan Reid, St. Louis, Mo.—A handsome collection of engravings, the subjects of which are the officials of the St. Louis Exposition, and the buildings and ornamental features as they will appear when completed. The book also contains explanatory paragraphs relating to the pictures of the buildings and other features.

DYNAMOTORS AND MOTOR-GENERATORS.—The Holtzer-Cabot Electric Company, Boston, Mass.—This is bulletin No. 139, superseding bulletin No. 103, and containing illustrated descriptions of a comprehensive line of dynamotors and motor-generators, which includes machines for every standard class of service thus far developed.

CORRESPONDENCE SCHOOL COURSES. American School of Correspondence, Chicago.—This is the December catalogue of this well-known school and contains a detail schedule of the regular and special courses of technical education covered by its curriculum. Synopses of the various subjects are also given, from which a prospective student may intelligently select the line of study best adapted to his needs.

THE NERNST LAMP. W. M. Sheehan & Company, New York.—A pocket-size pamphlet containing an illustrated description of the commercial forms of Nernst lamp, now built in this country, some strong arguments in favor of its use, and a comprehensive price-list of the various commercial types. The catalogue is profusely illustrated and should be of much interest as a handy reference book to those interested in the Nernst lamp.

CASE ENGINES. The New Britain Machine Company, New Britain, Conn.—This is a handsomely-executed book of standard catalogue size containing illustrations of all the different styles of gas engines, tables of dimensions and other data relating to these various types; a general description of the fundamental constructional features of the engine, and some illustrations of direct-connected gas engines and dynamos built by various manufacturers.

ENCLOSED-ARC LAMPS. The C. J. Toerring Company, Philadelphia.—This is bulletin No. 4, containing an illustrated description and price-lists of the Toerring enclosed-arc lamps for 110-volt and 220-volt direct-current circuits. The 110-volt lamps are built for 3, 4 and 5 amperes respectively, and the 220-volt lamps for 2½ and 3½ amperes. The lamps of both voltages are made in a large variety of finishes, and the standard casing is such that the lamp is equally well adapted for both indoor and outdoor service.

ENCLOSED-ARC LAMPS. The Shelby Electric Company, Shelby, Ohio.—As announced in our Business News department last month, the Shelby Company has perfected a line of enclosed-arc lamps for direct-current and alternating-current circuits, and the present publication is devoted to this line of apparatus. The lamps are built in standard and miniature sizes and embody the following features: Absence of springs, sliding contacts and wheels; simple adjustment for varying the amount of current passed; low operating temperature, and prompt starting the instant the carbons come in contact.

MOTOR-DRIVEN CENTRIFUGAL FANS. The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3,036, devoted to a line of centrifugal blowers direct-connected to Emerson alternating-current motors. The blowers are designed to give a pressure of one to two ounces per square inch in all sizes, the difference in size affecting only the volume of air delivered. The outfit is unusually compact, the motor being bolted directly to the side of the fan casing, so that the complete mechanism occupies not much more space than the fan alone. The catalogue also contains data and prices on pressure blowers for forges and similar service.

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BUSINESS NEWS.

H. D. MURDOCK, Pittsburg, Pa., reports that the sales of his cable insulator for 1902 were more than three times the sales in 1901, the number of insulators sold last year being over 60,000.

CATALOGUES WANTED.—George W. Scott, consulting engineer at 758 The Rookery, Chicago, desires descriptive catalogues of all electrical and other apparatus for filing, reference and specification purposes.

JAMES McCREA & COMPANY, Chicago, announce that the U. S. Water & Steam Supply Company, of Kansas City, Mo., has been appointed agent for the "Climax" steam joint clamp and will carry a complete stock of that article.

The CUTLER-HAMMER MANUFACTURING COMPANY, Milwaukee, Wis., has opened an office in Pittsburg, at No. 319 Frick Building, in charge of Mr. C. C. Badeau, formerly with the Wagner Electric Manufacturing Company, of St. Louis.

PITTSBURG GAGE & SUPPLY COMPANY, Pittsburg, Pa., reports among recent sales six boilers of 150 horse-power each to the Pittsburg Coal Company, and one boiler of similar size to the Pittsburg Tool and Drop Forge Company, Cheswick, Pa.

APPARATUS WANTED.—The Empire Manufacturing Company, Franklinville, N. Y., recently purchased the Citizens Electric Light plant of that city and desires circulars, catalogues, etc. It is the intention to instal a 100-h.p. engine and a 1,000-light incandescent dynamo.

THE SACHS ELECTRIC COMPANY, St. Louis, Mo., has just put on the market a lock box bell which is especially adapted for street car use, service in hotels, or any other place where it is necessary to prevent anyone tampering with the bell.

GEORGE W. HOFFMAN, Indianapolis, Ind., manufacturer of U. S. metal polish paste, powder, liquid and other specialties, reports that the demand for his product during the year just ended was double that of the preceding year and that he is shipping metal polish all over the world.

COMMERCIAL ELECTRICAL SUPPLY COMPANY, St. Louis, Mo., requests us to state that it has been appointed the representative for the Nernst Lamp Company in St. Louis and the surrounding territory, and carries a full stock of Nernst lamps.

THE REYNOLDS ELECTRIC COMPANY, Chicago, announces that its corporate name has been changed to the Reynolds Electric Flasher Manufacturing Company, and that its capital stock has been increased to $15,000, in order to enable the company to promptly meet the growing demand for its well-known electric sign flashers.

SHULTZ BELTING COMPANY, St. Louis, Mo., recently completed important extensions to its factory, which now contains a floor space of over 130,000 square feet. The company is now in a position to fill promptly all orders for its well-known leather and rawhide belting, lace leather, belt dressing, etc.

WESTERN ELECTRIC COMPANY, Chicago, reports very gratifying results with its constant-potential alternating-current arc lamp, and is also hard pressed with orders for Sunbeam incandescent lamps. The company was recently appointed Western selling agent for the house goods manufactured by Edwards & Company, of New York, and carries at the Chicago store a complete line of these goods.

OTIS ELEVATOR COMPANY'S recent contracts include the following: 10 hydraulic passenger elevators for the extension of the Manhattan Life Insurance Company's building, New York; eight hydraulic passenger and two hydraulic freight elevators for the Barclay Building, New York, and four hydraulic passenger elevators for the store of Frederick Loeser & Co., Brooklyn.

TELPHERAGE COAL PLANT.—The United Telpherage Company, of New York, has put in a telpher system for the Nashua Heat, Light, & Power Company, to handle coal from the spur track in the gas company's shed to the boiler rooms of the electric lighting plant. It is the first telpherage system in New Hampshire and reduces greatly the cost of handling the coal. About 75 tons a day will be regularly transported.

ROTH BROS. & COMPANY, of Chicago, have secured a contract for seven motors to be installed for general power purposes in the silk mills at Paterson, N. J., of the Benjamin Eastwood Company. There will be one 10-h.p., two 7½-h.p., two 5-h.p., and two 2-h.p. machines. An order has also been received from the General Manifold Company, of Franklin, Pa, for one 10-h.p., two 5-h.p., and four 2-h.p. motors.

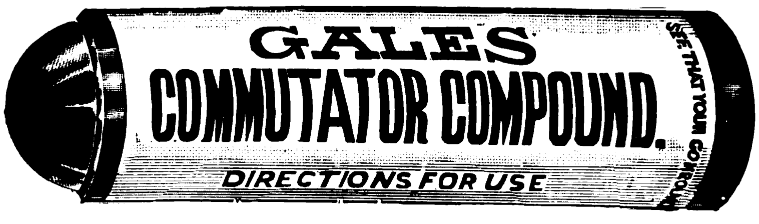
THE PITTSBURG ELECTRIC LAMP COMPANY, of Braddock, Pa., recently increased its capital stock from $25,000 to $75,000, and is now enlarging its plant to three times its previous size. This company is endeavoring to furnish the consumer with a strictly high-grade lamp and states that it will make no effort to put a cheap lamp on the market. Its business for the past 12 months has been most gratifying and as soon as the additions to the plant are completed the company will be in a position to fill orders more promptly.

PASS & SEYMOUR, of Solvay, N. Y., through its New York manager, W. Brewster Hull, recently succeeded in securing several fair-sized contracts for its specialties to be shipped to foreign countries. An order has been obtained through the Markt & Struller Company, New York, for a considerable number of fusible and fuseless rosettes for shipment to Mexico, and the Western Electric Company sent in a large order for sockets and rosettes to go to Australia. Among large domestic orders received within the last few days is one for several big transformer cut-outs to be shipped to the Kuhlmann Electric Company.

THE STERLING ELECTRICAL MANUFACTURING COMPANY, of Warren, Ohio, which has been meeting with much success with its regular line of incandescent lamps, has recently placed on the market a full line of miniature battery lamps, series lamps, multiple lamps and candelabra lamps ranging in candle power from ½ candle-power to 8 candle-power, and in voltage from 2½ volts to 125 volts. The company also has facilities for manufacturing telephone and elevator signal lamps; dental lamps, surgical lamps of all descriptions, and a new type of lens lamp.

THE BALL ENGINE CO., Erie Pa., recently sold to the McPherson Water & Electric Works, of McPherson, Kan., a 125-h.p. engine for direct connection to two General Electric generators; the United States Coal Company, Dillonvale, Ohio, is installing two 300-h.p. Ball engines, which are to be used for electric mining; the Osgood (Ind.) Light Company recently placed in operation one 125-h.p. direct-connected Ball engine, and the American Car Company, St. Louis, Mo., recently placed in operation a 100-h.p. direct-connected Ball engine. The Arkansas & Texas Consolidated Ice & Coal Company, Marshall, Tex., purchased a 200-h.p. Ball engine for electrical purposes.

A COMMUTATOR NECESSITY.



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The Only Article that will Prevent Sparking.
Will keep the commutator in good condition and Prevent Cutting.
Absolutely will not gum the brushes.
It will put that high gloss on the Commutator you have so long sought for.
50c. per Stick. $5.00 per Dozen.

K. McLENNAN & CO.
Sole Manufacturers,
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THE WAGNER-BULLOCK ELECTRIC COMPANY has closed a contract with the Stuparich Manufacturing Company to install a complete plant for the electrical operation of its large photographic-mount factory in San Francisco. A number of direct-current motors will be direct-connected to the various machines. The whole plant will be operated under the system upon which the Bullock Electric Manufacturing Company holds patents. A 50-k.w. generator, belted to a 100-h.p. Nordberg-Corliss engine, will supply current for the operation of the motors.

THE UNION RAILWAY COMPANY, of New York City, is about to build a large sub-station at West Farms, for which it has purchased from the Westinghouse Electric & Manufacturing Company a large amount of apparatus, including three 1,000-kw. three-phase rotary converters, with starting motors, self-cooling, oil-insulated transformers and alternating-current and direct-current switchboards. The transmission will be at 6,300 volts and 3,000 alternations. The alternating-current switchboard will be equipped with the new Westinghouse oil-break, electrically-operated switches. The Bayard Street station of the Metropolitan Street Railway Company, of New York City, is also being equipped with these switches.

THE ELECTRIC STORAGE BATTERY COMPANY, of Philadelphia, recently closed a contract with the Oakland Transit Consolidated, located at Oakland, Calif., for the installation of a battery of "Chloride" accumulators, consisting of 264 cells having a capacity of 550 kilowatts and to operate in connection with a booster. The battery is to be installed at the center of distribution of the system, about 2½ miles from the generating station. It is to be used to reduce the amount of feeder wire otherwise necessary and to regulate the fluctuations of load on the generators at the power house.

ROSSITER, MACGOVERN & CO., New York, have purchased the entire equipment of the 25th Street power house of the Metropolitan Street Railway Company, New York, comprising 4,000 kilowatts in generators. Three years ago this apparatus, which consists of 850-k.w. units, was considered the finest obtainable, but the rapid march of improvement has rendered it unavailable for present purposes. Most of this equipment has been sold to the Massachusetts Electric Companies and will be installed at the power house at Lowell, Mass. It will be recalled that Rossiter, MacGovern & Co. bought the 146th Street station equipment of the Metropolitan Company last year.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY recently closed a contract with the Sherwin-Williams Paint Company, Cleveland, Ohio, for three alternating-current generators and an equipment of induction motors, aggregating about 500 horse-power. The Newark works of the Sherwin-Williams Company, which was equipped some time ago with an alternating-current plant, will be provided with a duplicate of the original plant. Among recent important contracts closed by the Westinghouse Company for direct-current machinery was one for two 150-kw. machines and two 10-ton mining locomotives to go to the United States Coal Company's mines at Dillondale, Ohio.

THE BUCKEYE ENGINE COMPANY, of Salem, Ohio, through its New York manager, Paul Bigelow, has secured within the past few days a number of substantial contracts for engines to be used in lighting, power and general industrial plants throughout the country. The Binghamton (N. Y.) Light, Heat & Power Company has ordered a Buckeye simple engine for direct connection to a 350-kw. General Electric lighting generator. The E. M. Brown Paper Company, of Rock City Falls, N. Y., has ordered a 125-h.p. simple engine to be belted to a generator for lighting use. A similar engine to be used for a like purpose has been ordered by Bernhard Meiners, Erie Basin, Brooklyn, N. Y., and the Danbury & Bethel Power Company, of Danbury, Conn., has ordered a 300-h.p. Buckeye cross-compound engine for direct connection to a power generator of 200 kilowatts capacity.

THE VILTER MANUFACTURING COMPANY, Milwaukee, Wis., has recently closed contracts with the following parties for Corliss engines: Gutmann & Company, Chicago, Ill. (second order), 24x42; Wausau Paper Mills, Brokaw, Wis., tandem compound, 15x30x42; Louisiana Central Lumber Company, Clarks, La., 24x48; Wm. Henning, Vinegar Works, Chicago, Ill., 14x30; Lamar Light & Water Company, Lamar, Mo., 16x30; City Water & Light Department, Fort Atkinson, Wis., 18x36; Ewart Building, Chicago, Ill., 20x42; Warner Starch Company, Waukegan, Ill., twin 28x48; Hilgen Manufacturing Company, Cedarburg, Wis., 20x42; Rock Island Sash & Door Works, Rock Island, Ill., 30x48; American Candy Company, Milwaukee, Wis., 18x36; Boland & Gschwind Company, New Orleans, La., 20x42, 17x42, 22x42.

THE STOREY MOTOR & ELECTRIC COMPANY, of Harrison, N. J., is pushing matters actively. Its manufacturing department has been placed under the care of Mr. Thos. J. Fay as general manager, he having resigned from the C. W. Hunt Company. Mr. C. H. Shum, formerly of the La Roche Company, of this city, and the Bergmann Works in Germany, has been appointed electrical engineer; he is a Cornell graduate of 1895 and well qualified. The company has increased its machine tool equipment and is experiencing an excellent demand for its product, orders being many times greater than last year. The company is paying special attention to variable speed motors for direct-driven tools, and in this field its contracts are already abreast of its capacity for several months to come.

THE HEINE SAFETY BOILER COMPANY, of St. Louis, has secured a contract from Cerveceria Cuauhtemac, Monterey, Mexico, for the shipment of two boilers of 250 horse-power capacity each, for installation in an electric plant in Monterey. Among recent domestic orders is one for 1,050 horse-power in three units for the big new India Building, Boston, Mass., where the equipment will be utilized in connection with a large lighting and general power plant. The Reading Cement Company, of Reading, Pa., has ordered two 350-h.p. Heine boilers; the Jennings Electric Light and Power Company, of Jennings, La., has contracted for a 250-h.p. boiler; the Utah Electric Light and Power Company, of Salt Lake City, Utah, has ordered a Heine boiler of similar capacity, and the Philadelphia & Lehigh Valley Traction Company has ordered a 300-h.p. outfit for its Ambler, Pa., plant.

HARRISBURG ENGINE SALES.—MacKenzie & Quarrier, of 203 Broadway, New York, the recently established firm which handles the business in the East for the Harrisburg Foundry & Machine Works, have taken one order for two 250-h.p. standard engines, each for direct connection to General Electric generators of 160 kilowatts capacity, to be installed in the new plant of the Barber Asphalt Paving Company, at Warner, N. J. The machinery will be utilized for lighting and motor load. The Scranton, Pa., Electric Construction Company has ordered a 50-h.p. standard simple engine for direct coupling to a 35-k.w. General Electric dynamo for lighting purposes. Another order just to hand calls for two 100-h.p. standard tandem compound engines belted to 60-k.w. Stanley alternators, to be installed in an electric lighting plant at Huntington, L. I.

THE FRINK SYSTEM OF LIGHTING show windows and store interiors by special reflectors continues to prove its value. The manufacturer, I. P. Frink, New York, states that some of the more recent orders were from the following: Max Weil & Co., St. Louis, Mo.; Smith, Gray & Co., Brooklyn; Hecht's Stores, Baltimore; Segelbaum & Co., Braddock, Pa.; Parker, Bridget & Co., Washington, D. C.; J. Keller & Co., Kendallsville, Ind.; G. B. French Co., Portsmouth, N. H.; Goldsmith Bros., Easton, Pa.; Woodward & Lothrop, Washington, D C.; Gerardi Mercantile Co., Trinidad, Colo.; L. Bamberger & Co., Newark, N. J.; N. Snellenburg & Co., Philadelphia, Pa. Many of these names represent houses of national reputation; all are representative in their several localities, and whatever has the stamp of their approval may be safely adopted by progressive merchants everywhere.

THE HAINES & NOYES COMPANY, Chicago, has become affiliated with the Couch & Seeley Company, of Boston, Mass., and will in the future be the Western Department of the Couch & Seeley Company, with offices in Chicago. All prices will be f.o.b. Chicago for western selling, and a large stock will be carried in that city. The Couch & Seeley Company is one of the largest and oldest independent telephone manufacturing companies in the East, and its apparatus is too well known to need comment. The Haines & Noyes Company has been in existence but a little over two years,

Telephone Service is the Quickest Messenger.

Rates in Manhattan:

Business, from $5 a month.

Residence, from $4 a month.

One-Year Contracts.

Monthly Payments.

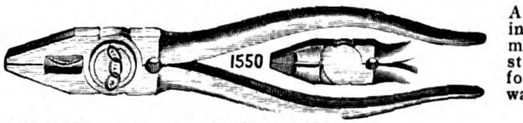
NEW YORK TELEPHONE CO.
15 Dey St. 111 West 38th St.
120 West 124th St.

SOLID TRAINS TO NORTHERN MICHIGAN.

The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.

All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

THREE TOOLS EMBODIED IN ONE.



A knot tying, splicing and side cutting plyer. An invaluable tool for linemen and electrical workmen. Forged from our special brand of Brescian steel and perfect in every detail. Send for the fourth edition of the GREEN BOOK of Hardware Specialties for further information.

Utica Drop Forge & Tool Co.
Mfrs. of Nippers & Plyers.

Smith, Hemenway & Co., Corp.
Mfrs. of Cutlery & Hdwe. Specialties,
296 Broadway, New York City.

An INCANDESCENT LAMP represents a large investment of cap'tal, ingenuity and skilled workmanship, it is sold at a price so low as to necessitate eternal vigilance in cutting costs to a minimum. A successful lamp manufacturer can not afford to experiment with poor materials. This explains the popularity of

BAKER & CO.'S PLATINUM

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We buy and Refine Platinum Scrap also

but has built up a large business and become well known throughout the telephone industry. All communications or orders from the West, including the Western part of Canada and Mexico, should be directed to The Haines & Noyes Company, while all communications and orders in the East should be directed to the Couch & Seeley Company, Boston, Mass.

THE CROCKER-WHEELER COMPANY, Ampere, N. J., reports among the shipments of engine type generators for a single month recently, one 400-kw. machine for the Stephen Girard Building, Philadelphia; one 100-kw. and one 125-kw. for the Missouri Pacific Railway, St. Louis; two 150-kw. for the Pennsylvania Malleable Company; one 200-kw. for J. L. Mitchell, Philadelphia; two 50-kw. for the Liveright & Greenwald Building, Philadelphia; two 100-kw. for the McClintic Marshall Construction Company, Pottstown, Pa.; one 300-kw. for the Grand Crossing Tack Company, Chicago; one 400-kw. for the Lake Construction Company, Erie Co., Pa.; one 250-kw. for the Wilmington City Electric Company, Wilmington, Del.; one 225-kw. for the Pine Bluff & Western Railway, Pine Bluff, Ark.; two 150-kw., one 200-kw., and one 75-kw. for the Woodward & Lothrop Building, Washington, D. C. The company reports that its new mill building is now occupied, enlarging the factory floor space by 60,000 square feet and giving correspondingly increased facilities for prompt deliveries.

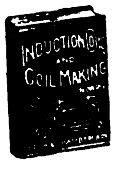
MECHANICAL DRAFT PLANT FOR ST. LOUIS EXPOSITION.—The mechanical draft equipment of the Union Electric Light & Power Company's plant, which will be used for lighting the World's Fair grounds at St. Louis, will be of unusual interest to engineers. The plant is to be equipped with both forced and induced draft apparatus, which is unusual. There will be 26 boilers of 700 horse-power each, equipped with automatic stokers; fans will be used for the forced draft, and the boilers will also be operated under induced draft. The forced-draft fans will be four in number, of the full housing type, size 160 inches. They will be driven by vertical engines directed-connected. There will be two induced draft fans, of a size quite in keeping with the scale on which the Exposition is being built, namely, 230 inches; the wheel diameters of these are of a magnitude seldom met with in mechanical draft engineering. They will be driven by double cylinder double-acting vertical engines. The Buffalo Force Company is building all the fans and engines for the plant.

E. H. ABADIE & COMPANY.—After several months of rest and recreation Mr. Abadie has formed a partnership with Mr. C. L. Michod under the name of E. H. Abadie & Co., with offices inthe Bank of Commerce Building, St. Louis, to carry on a general engineering and contracting business and acting in the capacity of manufacturers' agents for the sale of appartus for complete installations, among which are Habirshaw wires and cables, Wood apparatus and the new Elb-light system.

THE SPRAGUE ELECTRIC COMPANY, New York, is receiving many orders for its apparatus and reports among recent sales the following: Twenty 200-kw. turbine generators, three 75-kw. generators and four 20-kw. generators to the De Laval Steam Turbine Company, Trenton, N. J.; one 200-kw. belted type and one 200-kw. engine-type generator of the H. O. Wilburn, Philadelphia; one 200-kw. engine-type generator to the Otis Elevator Company, Yonkers; one 200-kw. belted-type generator to W. D. Ewart, Chicago; one 40-kw. and two 35-kw. belted-type generators to the Criterion Hotel, New York; one 75-kw. belted-type generator to C. Poyet, New York; one 50-kw. belted type generator to the American Express Company, Chicago; one 40-h.p. medium speed motor to J. F. Perkins Company, Brooklyn; one 15-h.p. "S. S." type motor to L. W. Pond Machinery & Foundry Company, Worcester, Mass.; one 40-h.p. belted-type motor to Miehle Printing Press Manufacturing Company, Chicago; two 20-h.p. "M. S." type motors to the Sigourney Tool Company, Hartford, Conn.; one 17-h.p. "S. S." type motor to the Martinique Apartment House, New York, and a large number of electric hoists.

THE C. & C. ELECTRIC COMPANY, of Garwood, N. J., and New York City, reports receipt of numerous orders for large motors and dynamos. A 225-k.w. generator has been ordered for power transmission purposes in the new Frazer & Chalmers Chicago shops of the Allis-Chalmers Company; the Lambert Hoisting Engine Company is erecting new shops at Newark, N. J., which will be equipped with a 100-k.w. and a 75-k.w. C. & C. generator, direct-connected to Phœnix Iron Works engines; the new apartment house under construction by W. H. Livingston, at 137 West Forty-seventh Street, New York, will have a 75-k.w. direct-connected generator and a 50-k.w. machine; one 50-h.p. and a 30-h.p. motor have been ordered for operating blowers in St. Patrick's Cathedral, New York; the Par Manufacturing Company, of Chicago, has requisitioned for seven special motors of 10 hore-power each, which are to be used for charging furnaces in the plant of the Illinois Steel Company; the Lister Agricultural Chemical Works, of Newark, N. J., has ordered a 35-h.p. motor for power use, being the sixth order received from this source; the St. Louis Water Works has sent an order for a 15-h.p. series-parallel equipment for use in a dredge; the Allentown (Pa.) rolling mills are to be equipped with four motors of 30 horse-power each; the new Horn & Horn restaurant building in Philadelphia is to be provided with two 60-k.w. C. & C. generators, to be direct-connected to New York Safety engines, and a large office building now under construction in Columbia, S. C., is to be provided with two 50-k.w. C. & C. generators, direct-connected to McEwen engines.

THE STANDARD UNDERGROUND CABLE COMPANY has just completed the erection of a large and thoroughly modern plant for rolling copper rods, drawing all sizes and shapes of bare wire, and insulating weatherproof wires and cables. This plant is an addition to the large underground cable factory and rubber insulated wire and cable factory at Perth Amboy, N. J., and enables the company to furnish bare rods and wire in any quantities, the capacity of the rod mill being 3,000,000 lbs. per month and the wire mill 2,000,000 lbs., single turn. The weatherproof factory will be in full operation by February 1, 1903, with a capacity of 500,000 lbs. of wire and cables per month, working single turn. The General Sales Department, with headquarters in Pittsburg, and the branch office managers at New York, Philadelphia and Chicago, remains the same. Mr. A. B. Saurman, who has represented the company in Boston for the past few years, goes to San Francisco, where he is associated with Mr. C. F. Sloane, the Pacific coast sales agent of the company, Mr. Saurman devoting his attention exclusively to the interests of the company on the coast. The Boston office is now in charge of Mr. Frank Clarke Cosby, formerly the company's representative in St. Louis. The New York office force is eaugmented by the presence of Mr. H. P. Kimball, formerly with the Williamsport Electric Company. Mr. R. M. Hirst, for several years connected with the Philadelphia office, will devote most of his time to the trade in the territory covered by the Philadelphia office. The Pittsburg office will have two men constantly on the road, Mr. A. A. Anderson, who has been with that office for several years, and Mr. McBride, formerly with the Pittsburg office, will be assisted by Mr. E. J. Pietzcker, formerly with the American Steel & Wire Company.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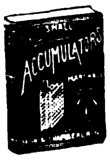

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Vol. XV. New York, February, 1903. No. 2.

ELECTRICAL EQUIPMENT OF A LARGE DEPARTMENT STORE.

THE ELECTRICAL EQUIPMENT OF THE NEW MACY STORE BUILDING.

BY CHAS. E. KNOX.

One of the latest examples in engineering practice in large isolated plants is found in the equipment of the mammoth department store building just completed for R. H. Macy & Co., New York. The building has a sub-basement, basement, nine main floors and two mezzanine floors. It is electrically lighted, and electricity is also used to drive motors for parcel conveyors, pneumatic blowers, carpet and sewing machines, ventilating fans, glass-cutting machines, laundry and kitchen machinery, etc.

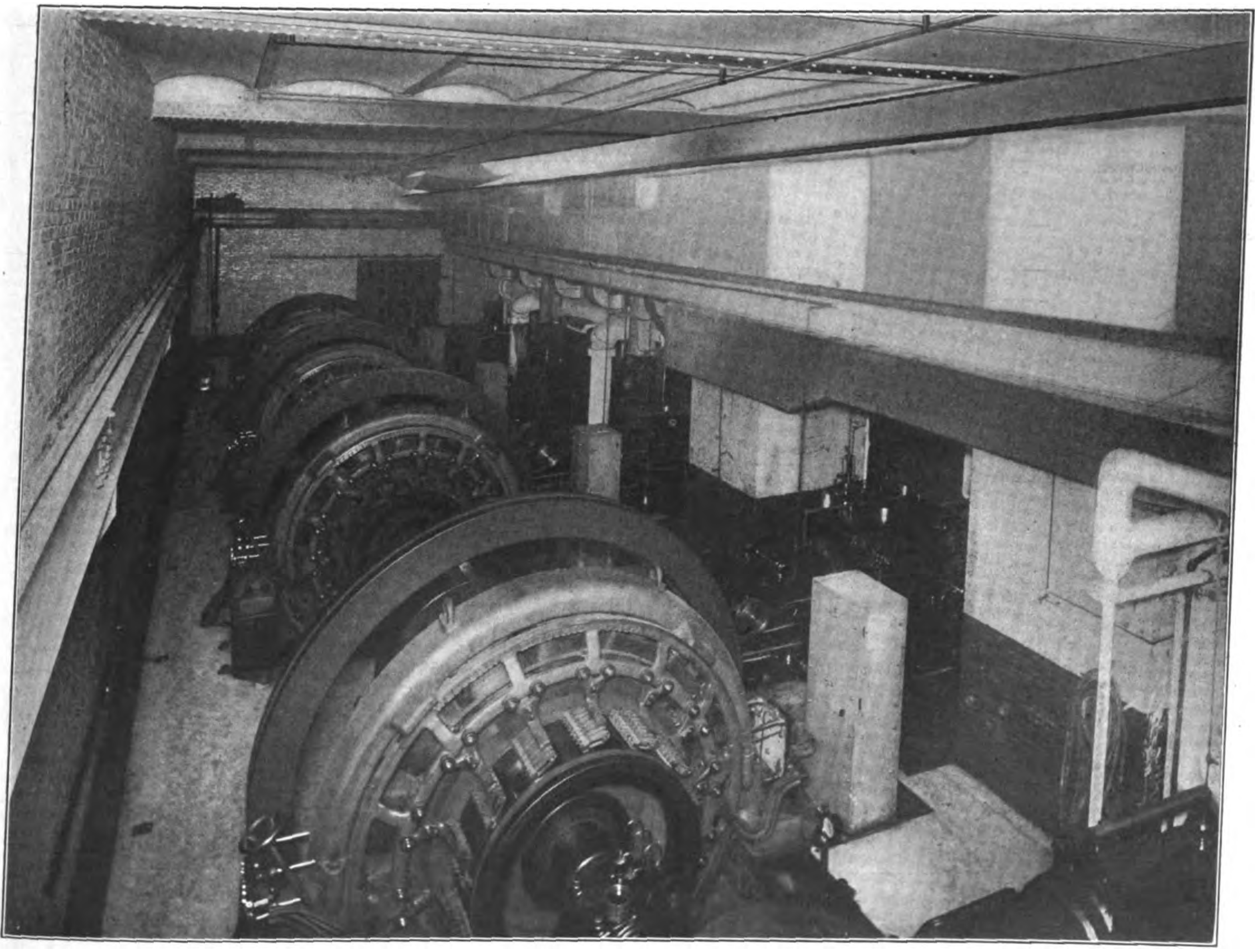

FIG. 1.—VIEW OF ENGINE ROOM IN R. H. MACY & CO.'S DEPARTMENT STORE BUILDING.

The current supply for the building is derived from a generating plant in the sub-basement. This plant has a total capacity of 2,000 kilowatts, and comprises four 400-kw. and two 200-kw. generators. These are 110-volt direct-current compound-wound machines and were built by the Western Electric Company. Each of the four larger (400-kw.) generators is direct-driven at 100 r.p.m. by a 600-h.p. horizontal tandem compound engine of the Rice & Sargent Corliss type, built by the Providence Engineering Works, of Providence, R. I. Each of the two smaller (200-kw.) generators is direct-driven at 200 r.p.m. by a 320-h.p. horizontal tandem compound high-speed engine, built by the Phoenix Iron Works, of Meadville, Pa. The engines are run non-condensing at 130 pounds initial pressure and no back pressure. The Paul vacuum system is used for circulating the exhaust steam for heating, thereby practically eliminating all back pressure.

The receivers between the high and the low pressure cylinders are provided with reheating coils, receiving steam at practically boiler pressure. A view of the engine-room and a plan showing the arrangement of the generating machinery, the switchboard, automatic switches and dynamo leads, are shown by Figs. 1 and 2 respectively.

The engines were bought under steam economy guarantees of not more than 18½ pounds of dry steam per indicated horsepower per hour at rated load for the Rice & Sargent engines and not more than 22 pounds of dry steam per indicated horsepower per hour at rated load for the smaller (Phoenix) engines.

All the generators and the feeder circuits for lighting and power throughout the building are controlled at the main switchboard in the engine-room. Owing to the size and length of the dynamo leads required to convey the current from the larger generators to the switchboard, and also to avoid complicated bus-bar work on the back of the generator panels of the switchboard, it was decided to obviate if possible the necessity of bringing the equalizer connection from the generators to the switchboard. Accordingly it was decided to place a special automatic dynamo switch at or near each generator, to be operated electrically from the main switchboard, and also adapted to be operated manually by means of a hand wheel at the switch itself. The location of these switches is shown in Fig. 2. As will be seen from this plan and also from the diagram, Fig. 5, the positive, negative and equalizer connections are in each case run from the generator to the corresponding automatic switch, and the positive and negative leads are extended to the main switchboard of course; the equalizer cables (which connect with the middle contacts of the automatic switch) are run between the various machines, as shown in Fig. 5, and do not connect with the switchboard at all.

Fig. 4 shows a view of the front of one of the automatic switches. Fig. 3 shows the motor for operating the switch, the switch chains and the terminal lugs. The switch is operated by its motor through gears and a toggle joint to the yoke holding the laminated switch contacts. The toggle joint is equipped with powerful coil springs which produce a quick make and break. As stated above, each automatic switch is controlled from the switchboard. A two-wire circuit is run from the positive and negative bus-bars and connects with the small double-pole switch and small double-pole circuit breaker; thence the circuit is extended underground to the automatic switch, where it connects, through a small auxiliary circuit-interrupting switch, with the electric motor.

The function of this auxiliary switch is to open the motor circuit switch at the instant, or more exactly, just before the main switch contacts are opened (or closed); the auxiliary switch is operated through an indirect mechanical connection with the toggle joint. As the toggle passes over the center, this switch is opened and immediately closed again on a similar set of contacts on the opposite side. The instant the circuit is interrupted by this switch, the small (underload) circuit-breaker at the switchboard is released and the motor circuit is thereby opened. The auxiliary switch is connected to the motor in such a manner

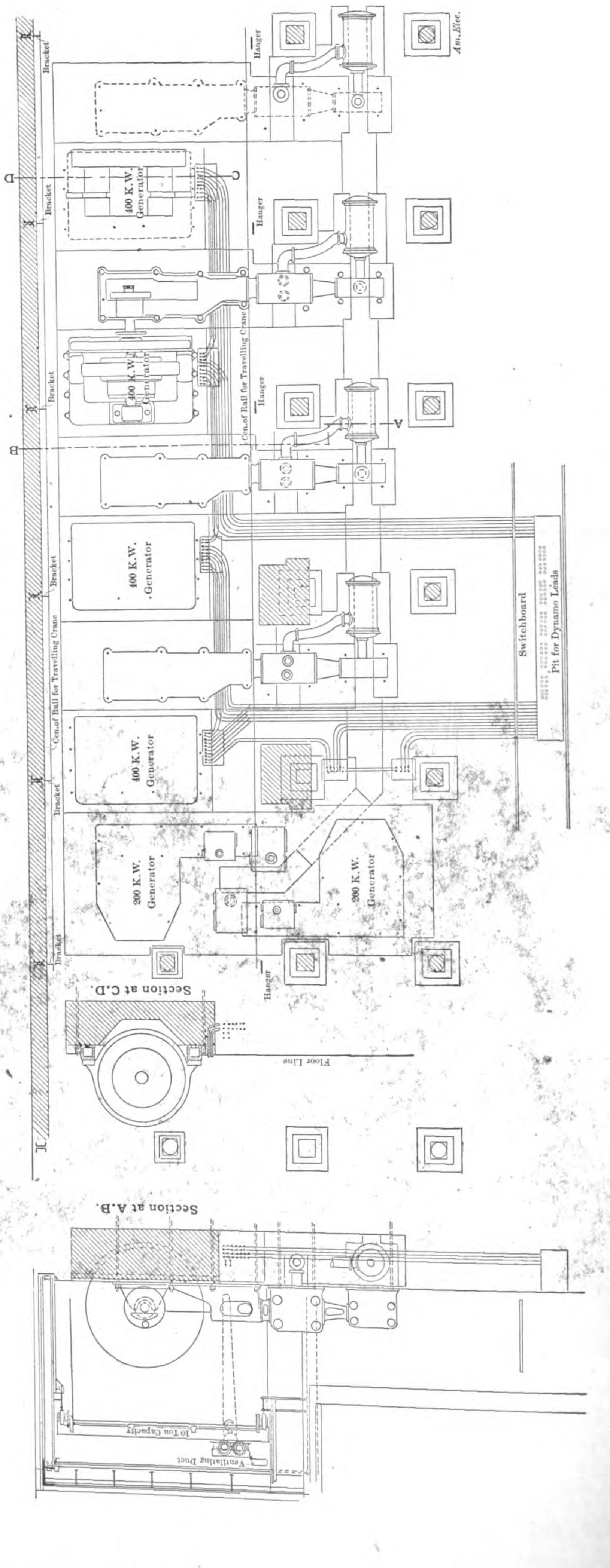

FIG. 2.—PLAN VIEW AND SIDE ELEVATION OF ENGINE ROOM IN THE MACY DEPARTMENT STORE BUILDING.

that the motor always runs in the same direction, whether the switch is in one position or the other. For the next operation it is only necessary to close the circuit-breaker, when the motor starts and the operation is repeated. The small double-pole knife-switch on the main board is left open when the dynamo is not in use, so that the liability of a mistake by throwing in the wrong dynamo is decreased.

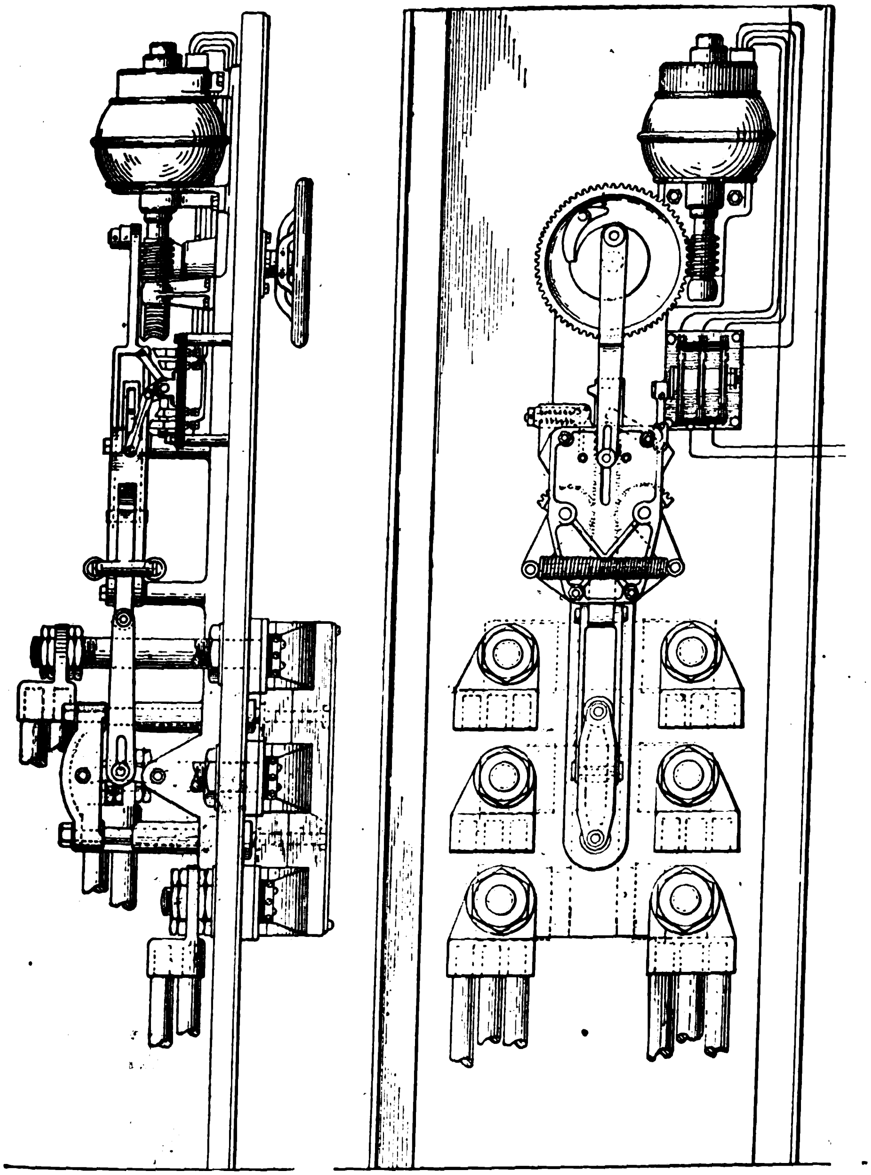

FIG. 3.—VIEWS SHOWING EQUALIZER SWITCH MECHANISM.

The equipment of the dynamo panel differs from the usual arrangement in several respects. In the first place, the equalizer bus-bar usually placed at the back of the dynamo panel is omitted, the equalizer connections between the dynamos being made at the automatic switches, as previously described. The second departure from the ordinary practice is the omission of the dynamo main (three-pole) switches. Each of these switches is replaced by a small knife-switch and small circuit-breaker which control the operating circuit for the three-pole automatic electromagnetic dynamo switch located near each dynamo. Single-pole automatic circuit-breakers are placed in each positive and negative dynamo lead.

All the dynamo main fuses are located behind the board, instead of at the front. A subsidiary panel set horizontally back of each of the dynamo panels, as shown in Fig. 9, serves to support the fuse connecting blocks and the dynamo lead terminal lugs. This arrangement is novel and has a great number of advantages.

The dynamo panel is equipped with two Chaovin & Arnoux registering ammeters and two recording (integrating) wattmeters, which serve to record respectively the current and power supplied to each of the two feeder panels. A registering voltmeter records the variations in the voltage of the dynamo bus-bars. At the left end of the generating panel a registering time-service indicator is to be placed to record the time at which each of the generators is placed in commission, and also the length of time it supplies current to the switchboard. This last named instrument was devised by the writer and will consist of six separate electromagnets, each operating a recording pencil corresponding to one of the six generators. The object of this instrument is to furnish the chief engineer with information as to the number of machines that have been in operation at any time during the day and the length of time each machine was in commission. By combining the record obtained from this instrument with the record obtained from the registering ammeters, it is possible to calculate the average load factor of each machine. In addition to these instruments a voltmeter, galvanometer and ground detector are placed on the generating panel. Space has been left on this panel for appliances for controlling an additional generator unit.

Each of the feeder panels contains three rows of double-pole single-throw knife-switches having eleven 400-ampere switches and twenty-two 500-ampere switches on each panel. A total load ammeter is placed on each of the feeder panels. As in the case of the dynamo panel, no fuses have been placed on the front of the switchboard for the feeder circuits. The feeder fuses are placed on small marble panels back of the bus-bar work, as shown in Fig. 9. These fuses are in three groups corresponding to the upper, middle and lower row of switches. In order to provide adequate and convenient space for removing and replacing the generator fuses, the fuses were put on a horizontal panel extending back from the generator panel. By this means it was possible to simplify the construction of the main bus-bars, and also the method of mak-

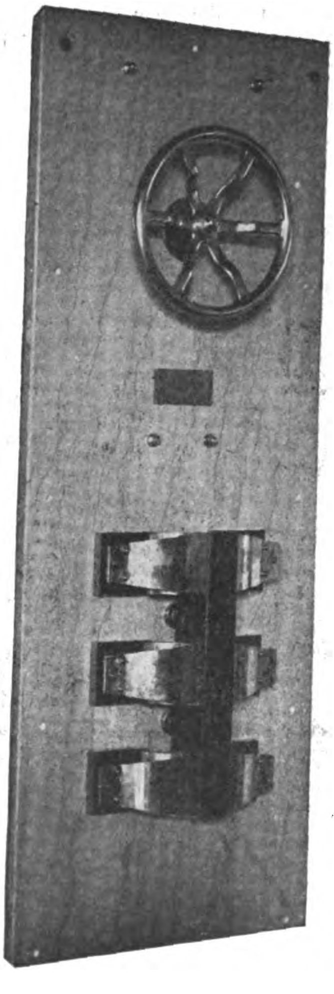

FIG. 4.—EQUALIZER SWITCH PANEL.

ing the dynamo lead connections; by this arrangement it was also possible to use proper tools for removing and replacing the generator fuses without being in danger of short-circuiting the generator bus-bars. The total length of the switchboard is 42 feet and its maximum height is 7 feet 10 inches. The bottom of the switchboard is twelve inches from the floor. The switchboard was designed by E. W. Müller, of C. O. Mailloux's office, and built and installed by the H. Krantz Manufacturing Company, of Brooklyn, N. Y.

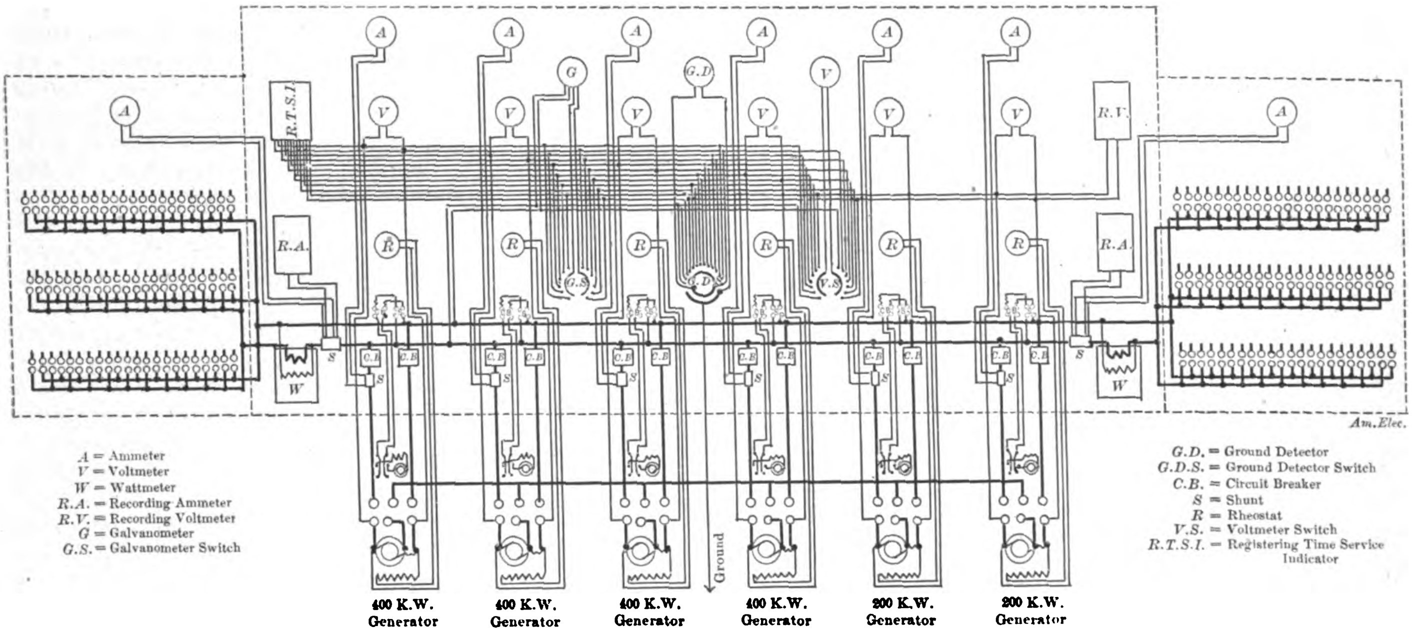
A = Ammeter
V = Voltmeter
W = Wattmeter
R.A. = Recording Ammeter
R.V. = Recording Voltmeter
G = Galvanometer
G.S. = Galvanometer Switch
G.D. = Ground Detector
G.D.S. = Ground Detector Switch
C.B. = Circuit Breaker
S = Shunt
R = Rheostat
V.S. = Voltmeter Switch
R.T.S.I. = Registering Time Service Indicator
R.T.S.I.
R.A.
R.V.
Ground
400 K.W. Generator
400 K.W. Generator
400 K.W. Generator
400 K.W. Generator
200 K.W. Generator
200 K.W. Generator
Am. Elec.

FIG. 5.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

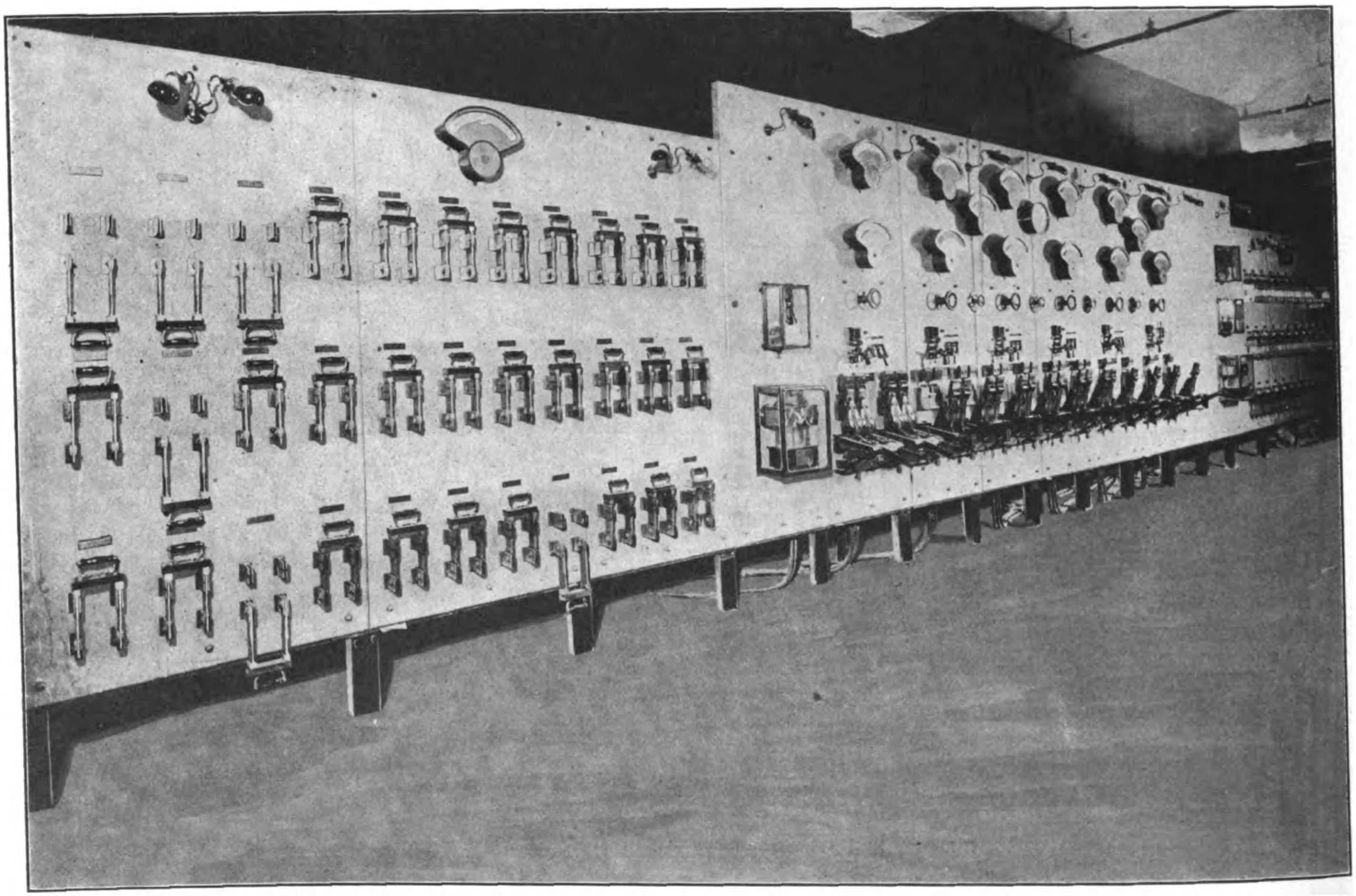

FIG. 6.—VIEW OF SWITCHBOARD IN THE MACY DEPARTMENT STORE BUILDING.

For the general illumination of the store, arc lamps of the enclosed type have been used throughout. Incandescent lamps are used for the outside sign illumination, the picture gallery, furniture department, show-case and window lighting, cash rooms, offices, work-rooms, etc. The total number of arc lamps wired for was 1,430. The total number of incandescent lamps wired for (including electric signs) was, approximately, 11,000.

Altogether, 1,200 enclosed arc lamps have been installed. These lamps, with the exception of a few miniature arc lamps under balcony, are all 5-ampere lamps, and were manufactured by the Jandus Arc Lamp Company, of Cleveland, Ohio. The lamps are adjusted for a potential difference at the terminals of 105 volts, with 80 volts at the arc. Both the inner and outer globes are of alabaster, having a density just sufficient to hide the arc from view. The pressure of 105 volts at the terminals of the lamp was decided upon as being the minimum voltage at which the lamps would work satisfactorily under all conditions; this allows a sufficient margin of resistance in case the carbons stick or short-circuit. The e.m.f. at the switchboard is maintained at 110 volts, five volts loss being allowed between the switchboard and the lamps; the resistance in the feeders, therefore, virtually forms a part of the steadying resistance for the lamps.

Under the balcony of the first floor miniature arc lamps of the 3-ampere type are used, partly owing to lack of head room and partly for the reason that a low candle-power arc lamp was needed at these points. As the greatest brilliancy was necessary in the basement and on the first and second floors, it was decided to place the arc lamps somewhat closer together on these floors than on the upper floors, and they were therefore placed 15 feet between centers in the direction running east and west, and midway between the columns (23 feet between centers) in the direction running north and south. On the upper floors the arc lamps are placed in the center of the bay in each case, being 21 feet between centers in the direction running east and west, and 23 feet between centers in the direction running north and south.

In order to have each arc lamp under individual control without resorting to ceil-

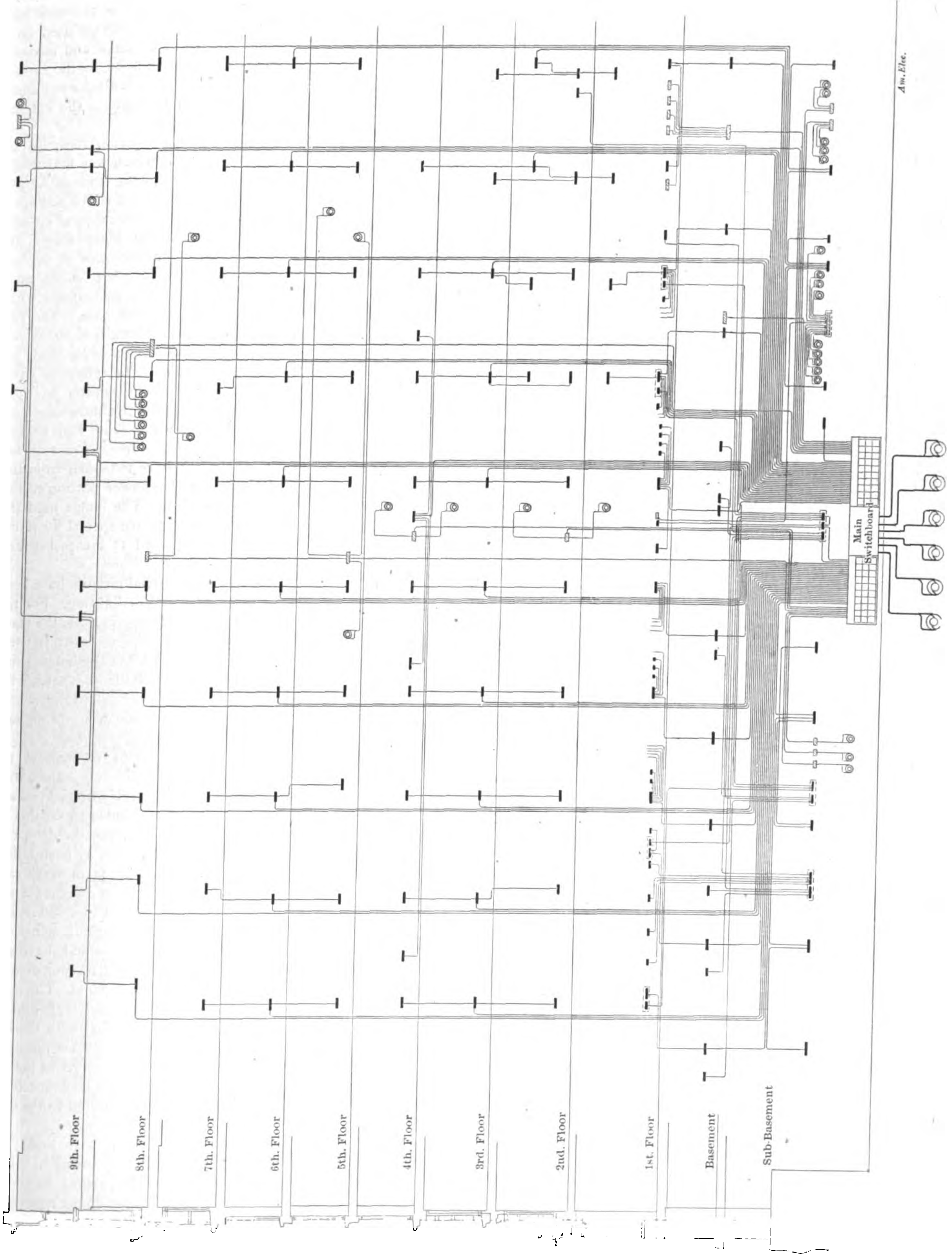

FIG. 7.—DIAGRAM OF DISTRIBUTION, SHOWING FEEDERS AND SUB-FEEDERS.

ing switches or to the use of poles for opening and closing the switch in the head of each arc lamp, it was decided to run a separate circuit to each lamp, and this course was adopted throughout the building.

For supplying the circuits of the various floors, ten centers of distribution symmetrically placed at equidistant points were located at each floor, from the basement to the ninth floor inclusive. On certain of the floors additional centers were located for lighting and power service required for special purposes. The general arrangement of the feeder system, centers of distribution, etc., are shown in Fig. 7.

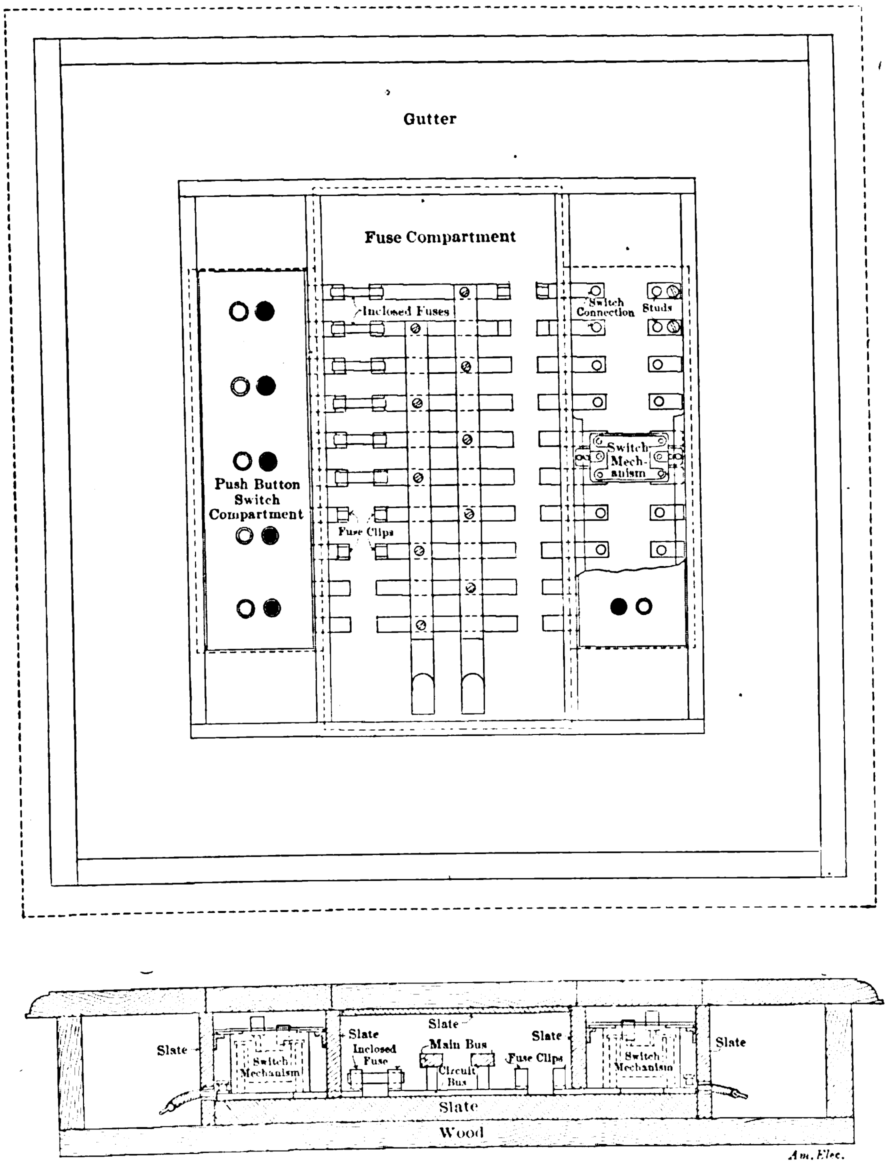

FIG. 8.—ELEVATION AND SECTIONAL VIEWS OF DISTRIBUTING PANEL.

The feeder circuits for the sub-basement are entirely separate from those of any of the other floors. This was deemed desirable because there is no natural light at all on this floor, and also for the reason that in case of accident to the power plant, and a limited current supply, the feeders for the remaining portions of the building could be cut off and this floor alone supplied with current until the trouble had been remedied. Certain of the centers of distribution for this floor serve as terminating points for the feeders; horizontal mains from these centers are extended to the other distributing points, as shown.

As a rule, at the upper floors horizontal runs of mains are avoided. Feeders are run to each of the ten distributing points of certain floors, and sub-feeders are extended to the corresponding distributing points of the floors above or below, or both, as shown in Fig. 7.

At the basement floor additional distributing centers are located for supplying circuits for lights in windows, on the stairs, in elevators, etc. A special feeder from the main switchboard to a main panel board in the sub-basement, from which mains are extended, supplies the stair and elevator lights throughout the entire building. Another feeder supplies the lights in windows, and the arcade and outside bracket lights on first floor. By providing separate feeders for these groups of lights, it is possible for the switchboard attendant to have these special lights fully under his control, so that they may be turned on and off at regular intervals each day without affecting the general circuits.

On the first floor additional centers of distribution have been provided for lights in show-cases. This lighting is one of the most important factors in the electrical equipment of the store. For this purpose it is obvious that no other form of artificial illumination yet known but the incandescent lamp can be used. The principal points to be borne in mind for show-case illumination are that the lamps must be hidden from the view of the customer and that the reflector used for this purpose should be as small and inconspicuous as possible. It must, at the same time, be so designed as to afford even and brilliant illumination throughout the entire show-case.

With this in view the writer designed a special reflecting outfit which was first used a number of years ago in the store of Abraham & Straus, Brooklyn, and which was eminently successful. This same type of reflector has been used at the Macy store. It consists of a continuous reflector of corrugated glass backed with sheet metal and painted mahogany color to correspond with the wood work of the show-case. The reflector extends the entire length of the show-case, the circuit connections being made in the corner of the case. The reflectors were made by the I. P. Frink Company, of New York. The conduits for the show-case circuits terminate in a water-proof floor outlet-box placed under the show-case in each instance. The circuits are extended from the floor outlet-box to the lower portion of the show-case in conduit. The lamps used for the show-case lighting are special 8-c.p. incandescent lamps placed 15 inches between centers.

As stated above, special circuits have been run for the show-window lighting. For the illumination of the show-windows, the standard type of Frink glass reflector is used, placed so as to avoid having the lamps shine in the eyes of the spectator and having the reflecting glass arranged so as to throw brilliant and uniform illumination throughout the entire show-window.

Each of the arc lamps throughout the building is controlled at the cut-out box from which the individual circuit originates, and as it was deemed undesirable to do this by means of knife-switches, fuse-holders, etc., it was decided to provide a push-button switch at each branch circuit in every case. For this purpose the writer designed a special form of cut-out, shown in Fig. 8. This consists of a separate cut-out panel arranged for enclosed fuses and having a separate push-button switch compartment at each side of the cut-out panel. The push-button switch is of a special type, and arranged for bottom connection with the bus-bars, as shown. The branch circuit wires, instead of being connected direct to the cut-out panel, were arranged to be connected to the short copper strip connected to the outer side of the switch in each case.

The switch compartment is lined with slate and in every case is provided with a separate door. By this arrangement it is possible to lock the fuse compartment and provide latches for the switch compartments, thus enabling the floor walkers, heads of departments, etc., to control the lights without making it possible to disturb the fuses or the cut-out portion of the panels. If desired, locks may also be put on the doors opening into the switch compartments and separate keys may be given to the proper parties for this purpose, instead of having the doors provided merely with a latch. This arrangement has proven far more satisfactory than the usual arrangement where knife-switches are used by persons unskilled in the use of electricity, because with a push-button switch it is impossible to improperly open or close the circuit. With a knife-switch, however, a floor-walker is very apt to open or close the circuit slowly, thereby causing arcing and ultimate destruction of the switch. The writer has known numerous cases where panel-boards have been practically destroyed by allowing the floor-walkers, saleswomen, etc., to have access to the panel-boards and to control the arc lamps by means of small knife-switches placed at the cut-out panels.

Two special feeders, originating and controlled at the main switchboard and terminating at distributing centers at the seventh floor, provide current for the outside sign lights. One of these signs consists of a star having a circular diameter of six feet. This sign is made up of a solid bank of 300 16-c.p. red lamps symmetrically arranged to form a star, the bulbs of which are of red glass. Below this the firm's name is spelled in eight-foot letters containing a total of 400 8-c.p. ground-glass lamps. The lamps are placed in a double row on the outer edges of the letter frames in each case. The signs were made by the Empire Electric Sign Company, of New York.

The plans and specifications for electrical equipment were prepared in the office of C. O. Mailloux, consulting engineer, of New York, under whose direction the work was installed. The work was installed by the George A. Fuller Company, who were the general contractors for the building.

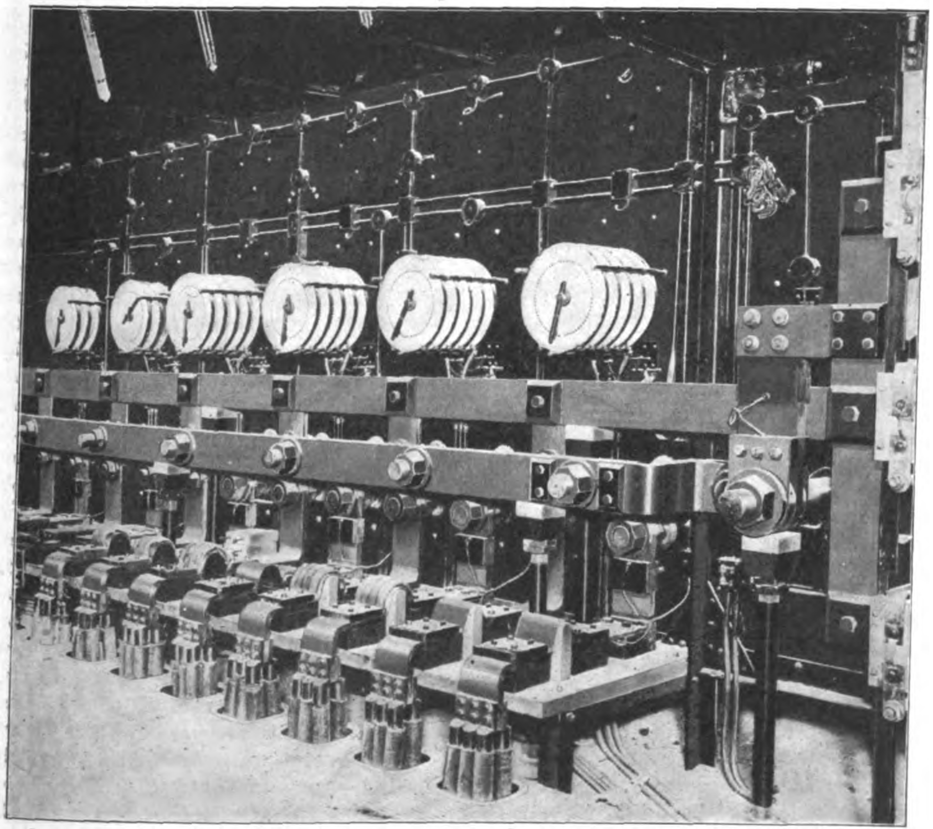

FIG. 9.—REAR VIEW OF SWITCHBOARD.

ACTION OF A SHUNT-WOUND MOTOR WHEN DRIVEN BY A SERIES-WOUND DYNAMO.

BY A. S. M'ALLISTER.

The operation of series-wound motors, when supplied from shunt-wound or compound-wound generators, is so familiar to everyone that the phenomena connected therewith are seldom given more than a passing thought. While no claim of practical utility can be made for the converse operation, *i. e.*, shunt-wound motors driven from series-wound generators, yet many features characteristic of such operation are sufficiently instructive to well repay the time and trouble of analyzing them.

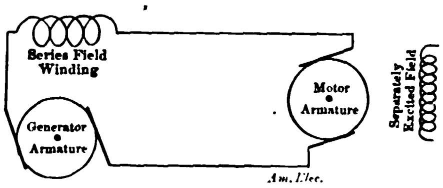

FIG. 1.

When the terminals of a series-wound dynamo are connected to the armature brushes of a motor, without load, and having constant field magnetism, as indicated diagrammatically by Fig. 1, the motor armature will not revolve continuously, but will run first in one direction and then in the other, continuing to reverse its direction of rotation at short intervals as long as it is kept in circuit. A little consideration will show that the reversals are due to the generator action of the motor during short periods when it is driven by its own stored energy of motion after its speed has increased to a value such as to cause its e. m. f. to equal and then overpower the then decreasing e. m. f. of the series-wound generator, thus sending a negative current through its own armature and the field winding and armature of the dynamo, which builds up e. m. f. in the reversed direction until it brings the motor armature to rest and causes it to pick up speed in the opposite direction of rotation.

A somewhat more complicated action is obtained when the motor is operated with a shunt field winding connected to its brushes in the usual manner, as indicated in Fig. 2. Under this condition, the motor armature will reverse repeatedly in much the same manner as before, but the action is due to causes quite different from those mentioned above. From observations made of the current in the circuit between the dynamo and the motor, of the e. m. f. at the motor brushes, the motor field current, and the speed, the curves of Fig. 3 have been plotted; these curves show more clearly than words can describe the instantaneous changes which occur.

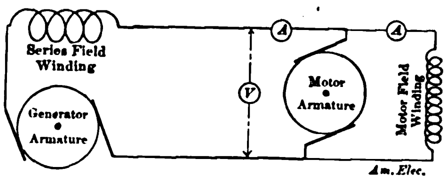

FIG. 2.

It will be noted that the field current lags in change of value as compared with the e. m. f. impressed at the terminals of the field winding. Since the field exciting circuit is a highly inductive one, such a result is naturally to be expected. Another phenomenon which evidently occurs, though not followed out graphically in the diagram, is a lag in the field magnetism behind changes in the strength of the field-exciting current, due to hysteresis. Obviously, the decreasing field magnetism will not reach zero until after the exciting current has reversed and reached such a value in the opposite direction that its magnetomotive force is sufficient to overcome the residual magnetism in the field magnet cores. It will be appreciated, therefore, that the field magnetism must lag in changes of strength behind the e. m. f. impressed at the terminals of the winding.

If the armature current and the field magnetism reversed precisely at the same instant, the torque would remain of its original sign, which for convenience may be called positive; no reversal of the armature would then occur. But partly because of the facts already mentioned the armature current reverses a considerable length of time before the field magnetism does, and hence the torque takes a negative value and the armature comes to a rest and reverses, running in the reversed direction until the field magnetism reverses also; then the torque becomes again positive, and the armature comes to a halt and changes back to its original direction of rotation.

In order to bring out these results more clearly consider the moment when the motor armature current, field exciting current, field magnetism, impressed e. m. f. and direction of rotation are all of the initial character, which we will designate as being of positive sign. The torque produced by the field magnetism and the armature current causes the armature to accelerate until its counter e. m. f. equals the e. m. f. impressed by the series-wound dynamo. As this condition is approached the armature current decreases and consequently the field magnetism of the dynamo also decreases, causing the e. m. f. impressed at the motor terminals to decrease. But the momentum of the armature continues its rotation, though with decreasing rate of speed, in a field of positive sign and only slightly decreased strength (owing to the lag of the magnetism behind the change in excitation). The counter e. m. f. of the motor, therefore, does not at once drop to zero, but causes a current of negative direction to flow through the motor armature and the armature and field winding of the dynamo. The exciting current in the winding of the motor does not immediately change its direction.

The reversed current in the field winding of the dynamo causes it to pick up e. m. f. in the negative direction, which further enhances the negative current in the armature circuit. There now flows a negative armature current of large value, under a field magnetism which thus far remains positive in sign. The interaction of these two produces a negative torque, so that the motor armature quickly comes to rest and reverses its direction of rotation.

The e. m. f. at the terminals of the motor field winding being now reversed (of negative direction), the field magnetism falls to zero and picks up in the negative direction as rapidly as the self-induction of the coils and the hysteresis of the cores will permit. When the field magnet excitation has risen to such a value as to just overcome the residual magnetism in the cores, the torque of the motor armature becomes zero, and its speed in the negative direction will have reached its maximum. As the field-exciting current increases further, the field magnetism builds up in the negative direction, and the torque, being now due to negative magnetism and negative current, becomes itself positive, so that the armature slows down, stops, and reverses its direction of rotation again, now running in its original direction.

As the speed increases, the counter e. m. f. increases, and finally reaches a point where it equals the e. m. f. impressed by the generator. The current in the line is then zero again, and the torque being also zero, the speed of the armature will begin to decrease, but the continued rotation will send a reversed current through the armature circuit and the field winding of the dynamo, as before, causing the various reversals described. These cycles of action are, of course, continuously repeated.

In the foregoing discussion, the effect of friction has been neglected. If the value of the friction be such, or if a load be put on of such a value, that the speed of the armature, after the torque becomes zero, falls so quickly that the counter e. m. f. cannot overcome the impressed e. m. f. from the dynamo, then the motor armature will revolve continuously in one direction.

It is to be observed that the hysteresis of the magnet cores and the self-induction of the exciting coils are not the only phenomena that contribute to the repeated reversals of the motor. There is another and entirely different cause. When the motor attains its maximum speed in one direction, say positive, and the dynamo e. m. f. becomes reversed, drawing a heavy negative current through the motor armature, the motor field magnetism would remain positive for a considerable length of time, irrespective of hysteresis and self-induction, for the reason that the counter e. m. f. of the motor armature is still positive, and the field exciting current, therefore, is also positive, subjecting the armature to a negative torque which causes it to slow down. But, since a decrease in speed entails a decrease in e. m. f. at the field terminals, no reversals could occur without the assistance of the self-induction of the winding and the hysteresis of the cores, as described.

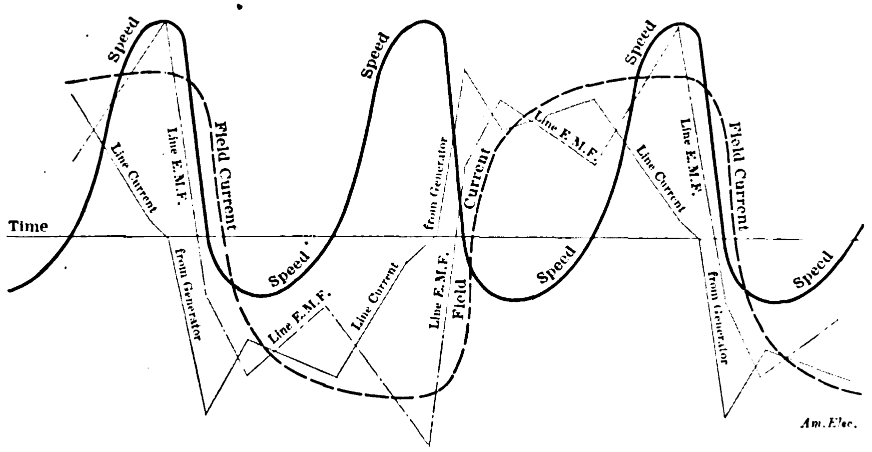

FIG. 3.—GRAPHIC REPRESENTATION OF PHENOMENA CONNECTED WITH THE OPERATION OF A SELF-EXCITED SHUNT MOTOR SUPPLIED FROM A SERIES GENERATOR.

* * *

Aluminum Wire Joint. — The best aluminum wire joint, out of 28 different types, is made as follows, according to W. M. Morrison, in a paper presented to the Institution of Electrical Engineers: The two ends of the wires are bent round each other, or simply butted together, they are then surrounded by a cigar-shaped mould in two halves which are clamped together and molten aluminum run in at a hole in the top. The mould is then removed.

TELEPHONE ENGINEERING.

Preservation of Timber.

BY F. J. DOMMERQUE.

The fact that poles have increased in value by about 25 per cent in the last four years is ample proof that poles of the proper sizes are becoming scarce, at least, in such places as are not too far away from the market. It therefore pays to consider means whereby poles and other construction material of similar kind can be made to last longer.

To prevent the disintegration of wood it is necessary either to take the moisture out of the wood, and after it is out, to prevent moisture and air from entering it again, or else to transform the moisture or the sap in the wood into a state in which it can neither dissolve nor ferment. At the present time the moisture or humidity is taken out of the wood by air drying or seasoning; but as stated before, after a year's air drying 20 to 25 per cent humidity still remains in the poles. Therefore the first step in the right direction would be to get this out. One method is to put the poles in closed iron tanks provided with a steam jacket. Steam is let into the jacket and the poles are heated to 212° Fah. To assist the evaporation, an air pump is connected to the tank to create a vacuum of two to three inches; or superheated steam is used. Another method is to build brick chambers with double walls separated by air chambers; after the poles are brought into these brick vaults upon specially constructed carriages, the gases of a furnace are permitted to circulate through the air chambers. The poles have to stay in the drying chamber for some days, the longer the better, of course.

When the moisture in the wood has been evaporated, certain substances remain that do not evaporate under the temperature to which the wood was exposed, and these substances are highly hygroscopic. Therefore something must be done to prevent moisture from entering again after the poles are set. For this purpose the poles could be painted; painting is always recommended when the poles are only air dried. In reality, however, it is too costly a process to steam the poles and subject them to the heated vacuum, and then only paint them; usually if one has gone that far, it is followed by the creosoting process, which will be discussed in the next article. Painting is the easiest way of keeping moisture out; it apparently should not be necessary to paint the whole pole, as experience has shown that the poles are attacked first and to the greatest extent at the surface of the ground; but water may enter from the top end of the pole, and also where the gains are cut—in short, everywhere that the water cannot run off freely. It seems, therefore, best to paint the pole all over, as the appearance also will be better; and to do something extra at the most exposed places.

What is commonly termed "paint" consists of two substances, namely, a specifically colored powder and an oil. Of the many oils suitable for this purpose linseed oil has become the standard on account of its great resistance when dry. Each particle of pigment, after being mixed with the oil, should be completely enveloped by the same. The principal conditions for obtaining good results in painting are the use of pure oil and a good pigment. The oil must be pure, because only then can it best take up the oxygen required for the drying process. Good linseed oil must not be too thick, else it has to be thinned with turpentine so as not to give too thick a coat; a thick coat having the objection that only the surface dries out thoroughly and cracks will soon appear in the coating. The pure oil has a yellow color; the yellow may be light or reddish, but never brownish; it should not smell; sometimes linseed oil smells fishy, which proves its adulteration with fish oil; it should taste bitter and disagreeable; it should be clear and not contain any particles suspended in it. If it is not clear, let it stand undisturbed for two weeks in a medium warm place; if unadulterated it will become clear and all particles previously suspended will settle to the bottom.

To ascertain whether the linseed oil has the proper capacity as a dryer, a plate of glass should be covered thinly with a coat of it; inside of twenty-four hours this coat should attain such a degree of dryness that no dust will stick to it, and in forty-eight hours it should be hard dry. Linseed oil when stored for any length of time where air has access to it will retain a certain amount of oxygen; some time will elapse before it begins to take up the oxygen, but when once started it will take it up rapidly; therefore it should be stored in air-tight receptacles; this rule applies also to all mixed paints.

The facility for drying depends greatly upon the temperature under which the oil is exposed to the air; moderately increased temperature enables the drying to proceed quickly. Therefore summer is the best time for painting.

As a rule, paint comes in the market already mixed. The pigments are either products of nature, as ochre, sienna, umber, etc., or chemical products like white lead, red lead, or chemical compositions of the heavy metals (iron, zinc, etc.) with oxygen. Any paint is at its best when the pigment is well mixed with and every particle of it completely surrounded by the linseed oil. As machinery is the best mixer, the reader is advised to buy paint already mixed, if the manufacturer can be relied upon to use unadulterated material. If the painter buys his own material and mixes it himself, he should do the mixing at the time he is going to use the paint, not before.

A pigment much used is white lead. It is heavy, pure white, easily powdered, not soluble in water but soluble in acetic acid, spirits of nitre and boiling muriatic acid. Pure white lead completely dissolves in a solution of one part of spirits of nitre and two parts water; the spirits of nitre must be chemically pure, of course. White lead possesses great adhesion and needs not more than 35 to 40 parts of oil to 100 parts of pigment. Such paints as possess great elasticity withstand best the influence of weather, heat and cold, dust and sand; as white lead requires less oil than other pigments it is not as durable and will lose its lustre and elasticity quicker and will soon crumble or peel off. But on account of its great adhesion and impregnability against water, white lead is a good medium to insert between two surfaces, as, for instance, into the gains.

As a rule the upper part of a pole is painted light and the lower part dark, whatever colors may be used. To paint the poles white and black, the requirements are as follows: For a 30-foot pole, 5¾ lbs. of white lead, ½ gallon of linseed oil and $^1/_{16}$ gallon of black paint. For a 40-foot pole, 8½ lbs. of white lead, ¾ gallon of linseed oil and $^1/_{12}$ gallon of black paint. For a 45-foot pole, 10 lbs. of white lead, ⅞ gallon of linseed oil and $^1/_{10}$ gallon of black paint. For a 50-foot pole, 10½ lbs. of white lead, 1 gallon of linseed oil and $^1/_{10}$ gallon of black paint.

Metallic paints are frequently used, principally for cross-arms and pins. Asphalt paints are of advantage in painting the inside of cable boxes. All these paints cover well, are durable and comparatively cheap.

* * *

DRIVING BOILER FEED PUMPS.

BY C. R. JAMES.

An argument frequently advanced by the opposers of electrically-driven boiler feed pumps in power houses is that they do not offer an opportunity for a sufficiently great variation in speed to meet ordinary conditions of practice without introducing wasteful resistance in the motor circuit. Of course it is true that considerable electrical energy could be thrown away in resistance without reducing the efficiency of the combination lower than that of the notoriously inefficient direct-acting steam pump. However, it is a matter that should not be disregarded and the suggestion made by a practical engineer recently as to a method of overcoming this may be worth trying. The suggestion was that a triplex pump be used, this pump to be driven either by an electric motor running at constant speed or by a belt from one of the main engines; or it might be driven at constant speed by a small variable cut-off steam engine which would give considerably greater economy than a direct-acting steam pump.

To cover the requirement for variation in the rate of pumping the suggestion was made that from the suction to the exhaust of one or two of the pump cylinders of the triplex pump a by-pass valve of large capacity should be placed. Then to vary the rate of pumping it would only be necessary to open the by-pass valves more or less. With the valves completely closed the pump would work at its maximum output. If there are by-pass valves for two of the cylinders of the pump, the opening of two of the valves to their fullest extent would cut down the rate of pumping two-thirds. Such a pump would, of course, be most economical when driven from one of the large main engines.

In point of fuel consumption the next best arrangement would probably be to drive the pump by means of an electric motor, but with this method the interest on the investment in the extra generator capacity must be figured. If the pump were driven by a small independent steam engine which will operate on 60 pounds of steam per indicated horse-power, as against 200 or 300 pounds for a direct-acting steam pump, there would still be considerable economy realized over a direct-acting steam pump.

* * *

A REMARKABLE CURRENT CONVERTER.

A most remarkable apparatus for the conversion of alternating into direct current has been developed by Mr. Peter Cooper Hewitt, as a result of his investigations of the properties of mercury vapor tubes. The apparatus consists merely of a vacuum bulb containing some mercury and several electrodes, the latter being connected to the circuits as indicated in Fig. 1. The operation of this remarkably simple converter depends upon peculiar properties of electrodes sealed in a receptacle containing vapor at a certain degree of attenuation; under this condition, the electrodes act as electric valves, permitting passage to one-half of the alternating-current wave and suppressing the other half. In this respect the apparatus differs from a rectifier, as the latter reverses the polarity of one-half of the alternating-current wave and thus doubles the frequency.

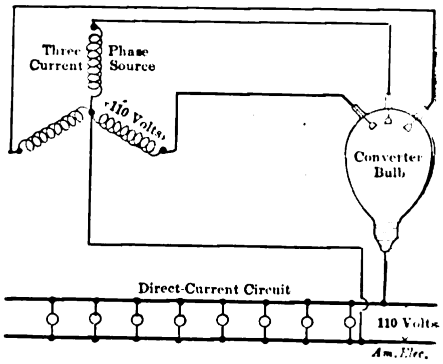

FIG. 1.—DIAGRAM OF CONNECTIONS.

The remarkable feature of the converter is its astonishing simplicity. A converter for 200 lamps, for example, is a little larger than a 100-c.p. incandescent lamp, and weighs but a few pounds. Fig. 2 shows a converter having a rated capacity of 8 kilowatts. The vapor globe is 7 inches in diameter and about 9 inches in extreme length; the weight is about 3 pounds. At the top are sealed four leading-in wires terminating at iron cup electrodes. One of these is used only in starting up, as will later be described, and the other three are for connection to the three leads of a three-phase circuit, as indicated in Fig. 1. The bottom electrode is connected to one side of the work circuit, the other side of which is connected to the neutral point of the alternating-current circuit.

When the tube is cold a greater resistance is opposed to the passage of current, necessitating a higher voltage at starting than the normal; this voltage is supplied to the fourth upper electrode from an auxiliary circuit which includes a boosting coil, for the very short period necessary to produce the proper condition in the tube to start up the discharge from the normal circuit. This starting arrangement, which is similar to that developed in connection with the Cooper Hewitt vapor light, can be made entirely automatic in action. With the 8-kw. converter here shown, as many as 180 16-c.p. lamps have been operated at full candle-power; this was the limit of the capacity of the small generator supplying the alternating current, and the indication was that the tube could have carried even a larger load.

Very shortly after the converter is put in circuit it attains a definite temperature at which it will operate indefinitely. The amount of heat to be dissipated by the bulb is a direct function of the drop, which is 14 volts, and the dimensions of a bulb can, of course, be quite accurately fixed to dissipate the heat corresponding to a given load.

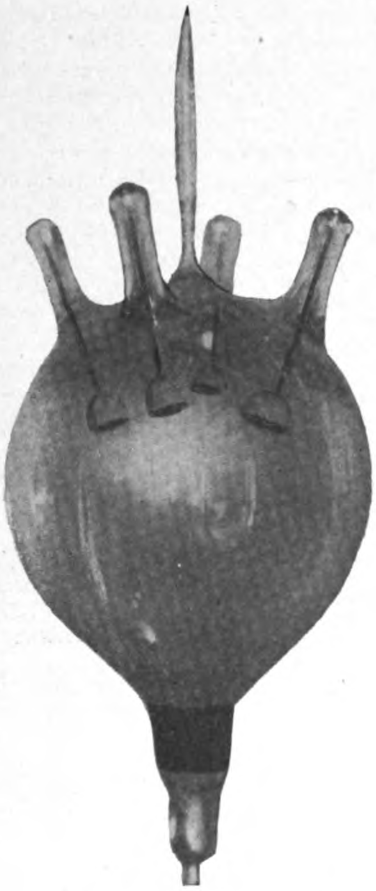

FIG. 2.—STATIC CONVERTER.

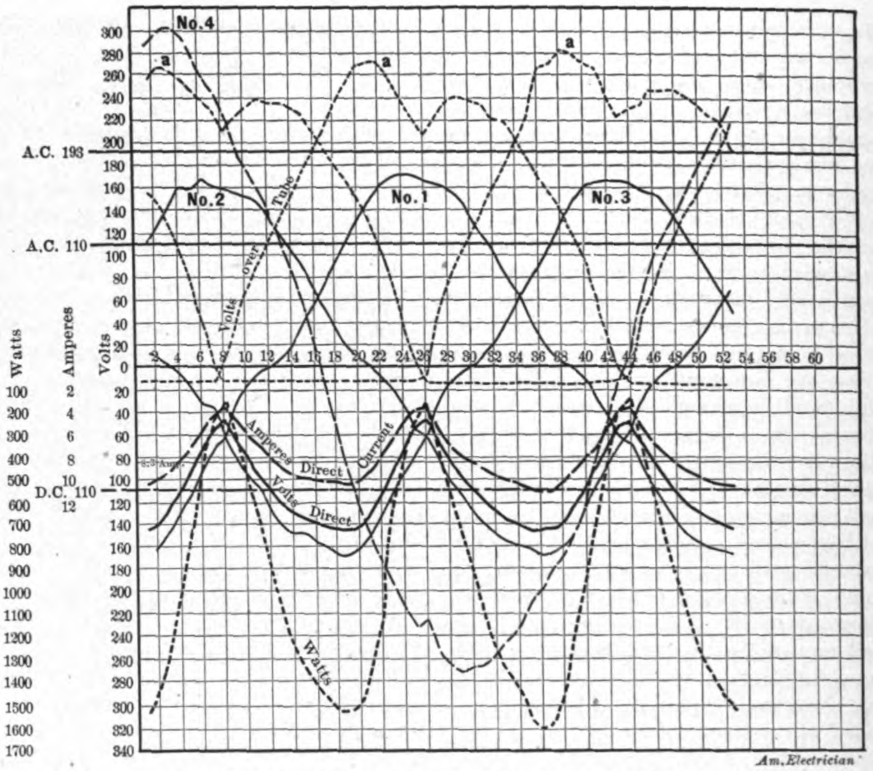

FIG. 3.—DATA APPLIED TO RECTANGULAR CO-ORDINATES.

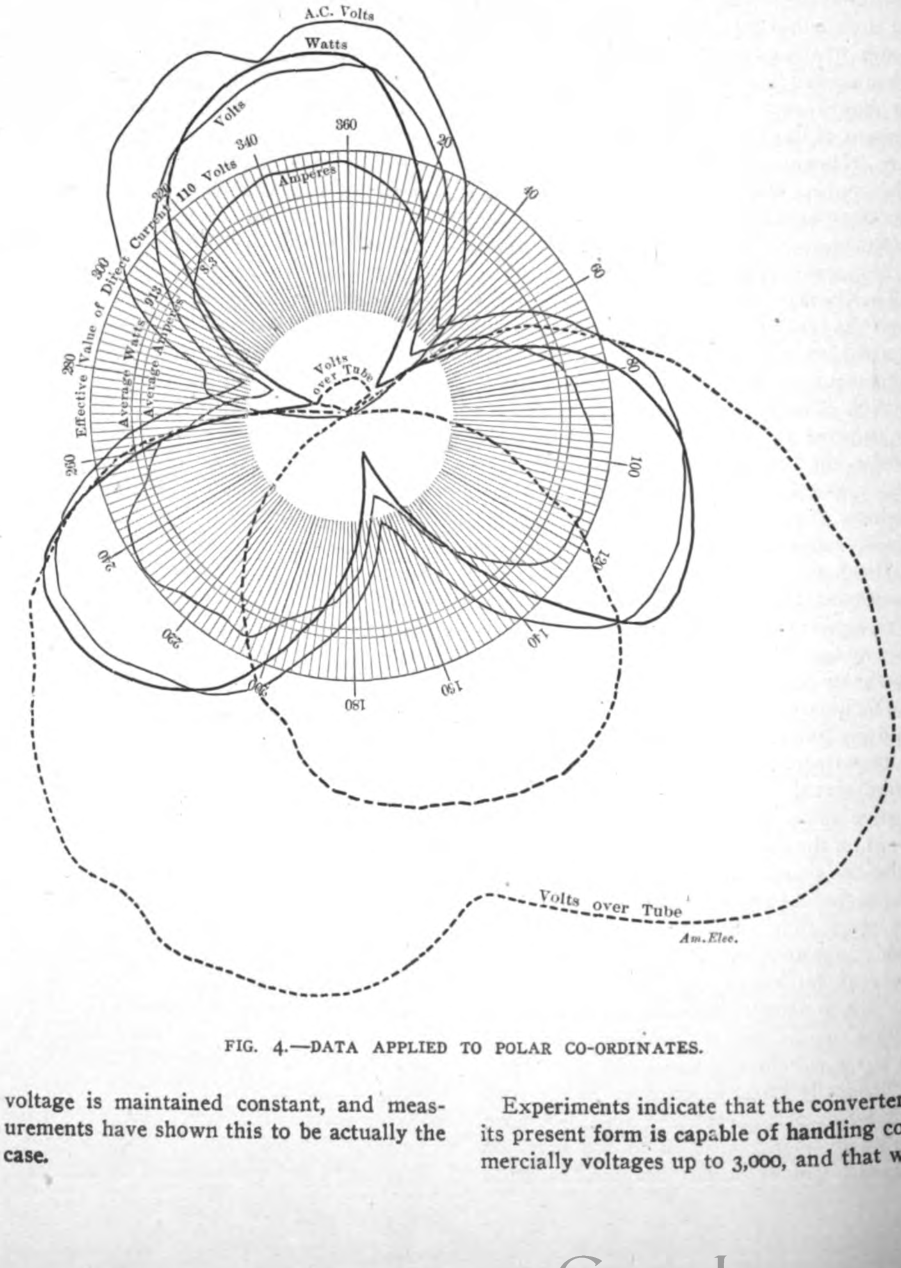

FIG. 4.—DATA APPLIED TO POLAR CO-ORDINATES.

A peculiarity of the system is the fact that the drop of 14 volts between the upper electrodes and the bottom one is constant at all voltages and at all loads on the converter. That is to say, this drop remains the same whether the current passing is that for one lamp or for 180 lamps, and whether the circuit voltage is 100 or 1,000. From this the efficiency of the apparatus can be very simply determined for any given voltage. The converter illustrated has been operated at a voltage as high as 1,800, in which case the efficiency is slightly over 99 per cent. It follows that the voltage delivered to the working circuit is constant for all loads, provided the impressed voltage is maintained constant, and measurements have shown this to be actually the case.

Experiments indicate that the converter in its present form is capable of handling commercially voltages up to 3,000, and that with further improvements the range may be extended to 10,000 volts. Up to the present stage, only glass bulbs have been used, but the principle admits of the use of steel shells, in which case the shell would form the negative electrode, the positive electrodes entering through insulating material, such as glass or porcelain.

Figs. 3 and 4 are curves laid down from data taken with a converter in regular operation, the data being applied to rectangular co-ordinates in Fig. 3 and to polar co-ordinates in Fig. 4. The curves *1*, *2* and *3*, represent the waves of the e.m.fs. induced in the three windings of the generator respectively. Curve *4* is the wave of e.m.f. between the generator terminals of windings *2* and *3*, the corresponding curves of the other terminal voltages not being laid down. The curves *a*, *a*, *a*, are the three e.m.f. waves plotted from measurements taken between each of the upper terminals and the lower terminal of the converter. The e.m.f. curve of the work circuit is shown in heavy line, the corresponding current and watt curves being shown in dotted and broken line, respectively. The form of the curves *a*, *a*, *a*, indicates very clearly the electric valve action of the electrodes in suppressing one-half of each alternating-current wave. This action is usually apparent at a very low frequency, when the succession of impulses from the several upper to the lower electrode can be followed by observing the vapor streams. It is interesting to note that the mass of mercury forming the lower electrode has a rotative motion, the angular velocity of which varies with the frequency.

By reference to the curves it will be seen that the effective voltage of the pulsating current corresponds exactly to that generated in the individual sections of the Y-winding of the generator. In the machine used in these particular tests, the voltage from the neutral point to each terminal was 110, the voltage between any two terminals of the machine and any two of the upper electrodes of the bulb was 193, and that of the pulsating direct current 110. In this, as in all other tests, the drop between the upper and lower electrodes was 14 volts.

It will be noted that the curve in the working circuit is that of a direct pulsating current. If more than three phases were delivered to the converter, the working e.m.f. would, of course, have less difference between its maximum and minimum value; that is, the current would more nearly approach a continuous current. In this respect, the action of the converter may be compared with that of a commutator, a three-phase converter corresponding to a three-part commutator, a six-phase converter to a six-part commutator, etc.

◆◆◆

Maximum Circular Valve Opening. — To obtain the maximum opening of any circular valve it is necessary to raise the valve off its seat a distance equal to one-quarter of its diameter. A valve five inches in diameter, for example, has 19.635 square inches area, and when raised 1¼ inches gives full opening.

ELECTRIC CONTROL FOR ELEVATORS.

The Single Push-Button System.

BY H. D. JAMES.

A modification—or, rather, elaboration—of the magnet system of elevator control that has come into wide use is the semi-automatic push-button system, the fundamental features of which are illustrated in diagram by Fig. 1 herewith. The movements of the car are controlled primarily by a series of push-button switches in the car and a duplicate series of similar switches distributed one on each floor. Simply pressing the switch button on a floor brings the car to that floor, provided it is not in use at the moment. When one is in the car, pressing the button corresponding to the desired floor causes the car to go to that floor and stop automatically there.

The system also includes a series of safety contacts, one on each landing door, which prevents the car-controlling magnets from receiving current while any door is open; these are indicated at the upper part of the diagram, which represents the circuits for a three-floor outfit. The wires *a* and *b* are the main leads of the controlling circuit, so that the current for switch magnets passes through the door contacts in series, and all doors must therefore be closed before the magnets can be excited.

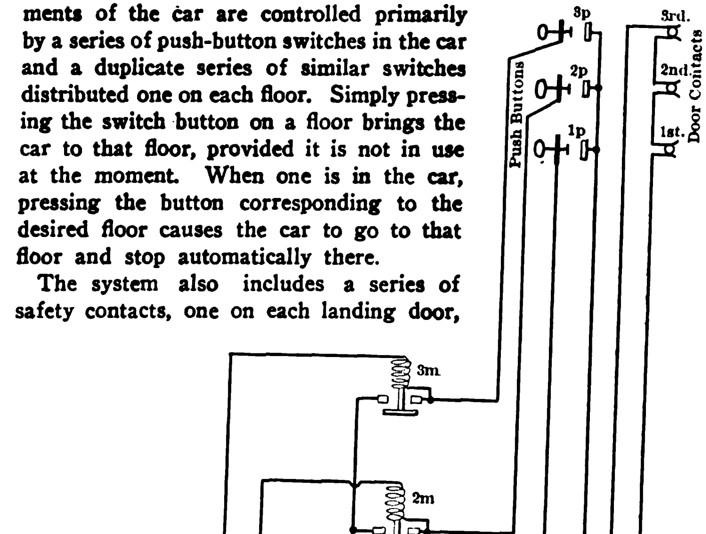

FIG. 1.—SINGLE PUSH BUTTON SYSTEM FOR ELEVATOR CONTROL.

The selective operation is accomplished by means of a rotating contact drum, designated "Landing controller" in the diagram, in conjunction with the small solenoid switches, *1m*, *2m* and *3m*. The solenoid switch *B* is a non-interference switch that prevents conflict between two attempts to control the car made within a few moments of each other. The landing controller drum is geared to the elevator hoisting mechanism so that when the car travels the full length of the shaft the drum makes not quite half a revolution; in the diagram the car is supposed to be at the top of the hatchway, and the controller drum has put all of the push-button circuits in connection with the "down" switch, through the brush *D*. Now, if one were to press the button *1p* on the first floor, the solenoid *1m* would be energized and close its circuit through the wire *f* and the solenoid *B*, so that releasing the push-button *1p* would not release the plunger of the solenoid *1m*. The circuit of this solenoid is completed to the positive wire through the "down" switch magnet, which is therefore energized at the same instant, and puts the motor in operation in the proper direction. The solenoid *B* is also energized at the moment the push-button is pressed, and lifts its plunger, thereby opening the wire *e* that leads to all the push-buttons; this renders it impossible for any one to interfere by pressing one of the buttons.

When the car approaches the first floor the gap *g* on the landing controller drum will be opposite the brush *1* and the control circuit (positive line-*a*-*b*-*B*-*f*-*1m*-*1*-*D*-down switch-negative line) will be opened, bringing the motor to rest with the car at the landing. The gaps in the controller drum surface are wider than the brushes *D*, *1*, *2*, *3*, *U*, to a sufficient extent to insure the release of the various magnets before the gap has passed the brush and transferred it to the other segment.

The push-buttons in the car are connected each in parallel with the landing push-button of the same number. The "up" and "down" switches make the main connections of the motor in the usual manner. The reference letters, *d* +, *u* —, etc., at the motor brushes in the diagram indicate the polarity for each direction of travel, *d* meaning down and *u* up. The field winding of the motor is connected in parallel with the winding of the brake-release magnet, so that the inductive discharge when the line circuit is opened will not puncture the insulation.

PRONY BRAKES FOR MOTOR TESTING.

The familiar form of prony brake shown by Fig. 1 and honored almost exclusively by old age is probably the least efficacious of all types, and undoubtedly offers the most difficulties in obtaining anything like accurate results. A type that has in one form or another almost entirely supplanted the clamp type is the band brake shown by Fig. 2, which comprises a leather belt secured to the floor at one end and drawn by means of weights into contact with the periphery of the pulley on the tested machine. The belt is prevented from slipping off the edge of the pulley by wooden strips secured to it at intervals, the strips being cut away on the under side so as to leave a lug at each end projecting below the edge of the pulley. This type of brake is very good for testing machines of moderate power; the formula for it is

$$\frac{\pi\, D.\, W.\, r.p.m.}{33{,}000} = H.\ P.,$$

in which D is the pulley diameter *in feet*, and W the pounds of weight at the scale-pan, including that of the pan. Expressing the pulley diameter in inches the formula becomes

$$\frac{\pi\, d\, W\, r.p.m.}{396{,}000} = H.\ P.$$

For testing heavy powers, such as that of a good-sized steam engine or very large electric motor, the form of band brake shown by Fig. 3 is commonly used. This consists of a series of wooden brake shoes fastened at equal intervals to a flexible strap of either leather or steel, preferably steel. The friction between the brake-shoes and the pulley face is adjustable by means of the bolt and lugs at *A*, and the effort to turn the brake with the pulley is registered on an ordinary platform scale by the downward pressure at *P*. This form of brake has given very good practical results, although it has an objectionable characteristic in common with the clamp form of Fig. 1, though in a much less degree, that is, it is liable to stick and release alternately, in the vicinity of the adjusting bolt, giving jerky impulses at *P*.

An excellent improvement on this type that was suggested several years ago by Mr. E. J. Armstrong is shown by Fig. 4. The improvement consists in locating the adjusting screw at the bottom instead of the top of the pulley, so that the strain on it is more nearly constant (with a given adjustment) and taking up any slight variations by means of a strong helical spring. The formula for the two brakes shown by Figs. 3 and 4 is

$$\frac{\pi\, L\, W\, r.p.m.}{16{,}500} = H.\ P.,$$

in which L is the length of the lever arm in feet, measured from the center of the shaft straight to the point of pressure, P, as indicated by the dotted line, and W is the weight in pounds recorded by the scale. In order to facilitate the computation, it is the general custom to make the distance L a small trifle over 63 inches (the accurate length would be 63.024 inches). Then the formula becomes $\frac{W\, r.p.m.}{1{,}000} = H.\ P.$

TABLE I.—PRONY BRAKE.

Giving weights corresponding to various horse-pow ers and speeds, with a brake arm 71⅝ inches long. Numbers in body of table are pounds.

Rev. per Min.	Horse-Power delivered to Brake:																					
	100	110	120	125	130	140	150	160	170	175	180	190	200	225	250	275	300	325	350	400	450	500
100	880	968	1056	1100	1144	1232	1320	1408	1496	1540	1584	1672	1760	1980	2200	2420	2640	2860	3080	3520	3960	4400
110	800	880	960	1000	1040	1120	1200	1280	1360	1400	1440	1520	1600	1800	2000	2200	2400	2600	2800	3200	3600	4000
120	733	807	880	917	953	1027	1100	1174	1247	1283	1320	1393	1467	1650	1833	2017	2200	2383	2567	2933	3300	3667
125	704	774	845	880	915	986	1056	1127	1197	1232	1267	1338	1408	1584	1760	1936	2112	2288	2464	2816	3168	3520
130	677	745	812	846	880	948	1015	1083	1151	1185	1219	1286	1354	1523	1692	1862	2031	2200	2369	2708	3046	3385
140	629	692	754	786	817	880	943	1006	1069	1100	1132	1194	1257	1414	1572	1729	1886	2043	2200	2514	2829	3143
150	587	645	704	733	763	821	880	939	997	1027	1056	1115	1173	1320	1467	1613	1760	1907	2053	2347	2640	2933
160	550	605	660	688	715	770	825	880	935	963	990	1045	1100	1238	1375	1513	1650	1788	1925	2200	2475	2750
170	518	570	621	647	673	725	777	828	880	906	932	984	1035	1165	1294	1424	1553	1683	1812	2071	2329	2588
175	503	553	604	629	654	704	754	805	855	880	905	956	1006	1132	1257	1383	1509	1635	1760	2012	2263	2515
180	489	538	587	611	636	685	733	782	831	856	880	929	978	1100	1222	1345	1467	1589	1711	1956	2200	2445
190	463½	509½	556	579	602	649	695	741	788	811	834	880	926	1042	1158	1274	1390	1505	1621	1853	2084	2316
200	440	484	528	550	572	616	660	704	748	770	792	836	880	990	1100	1210	1320	1430	1540	1760	1980	2200
210	419	461	503	524	545	587	629	671	712	733	754	796	838	943	1048	1153	1257	1362	1467	1676	1886	2095
220	400	440	480	500	520	560	600	640	680	700	720	760	800	900	1000	1100	1200	1300	1400	1600	1800	2000
225	391	430½	469½	489	508½	548	587	626	665	685	704	743	782	880	978	1076	1174	1271	1369	1565	1760	1956
230	382½	421	459	478½	497½	535½	574	612	651	670	689	727	765	861	957	1052	1148	1244	1339	1531	1722	1913
240	367	403½	440	458½	477	513½	550	587	624	642	660	697	733	825	917	1008	1100	1192	1283	1467	1650	1833
250	352	387½	422½	440	457½	493	528	563	598½	616	633	669	704	792	880	968	1056	1144	1232	1408	1584	1760
260	338½	372½	406	423	440	474	507½	541½	575½	592½	609	643	677	762	846	931	1015	1100	1185	1354	1523	1692
270	326	358½	391	407½	424	456½	489	521½	554	570½	587	619	652	733	815	896	978	1059	1141	1304	1467	1630
275	320	352	384	400	416	448	480	512	544	560	576	608	640	720	800	880	960	1040	1120	1280	1440	1600
280	314½	346	377	393	408½	440	471½	503	534½	550	566	597	629	707	786	864	943	1022	1100	1257	1414	1572
290	303½	334	364	379½	394½	425	455½	485½	516	531	546½	576½	607	683	759	835	911	986	1062	1214	1366	1517
300	293½	323	352	366½	381½	410½	440	469½	498½	513½	528	557½	587	660	733	807	880	953	1027	1173	1320	1467
310	284	312½	340½	355	369	397½	426	454½	482½	497	511	539½	568	639	710	781	852	923	994	1136	1278	1419
320	275	302½	330	344	357½	385	412½	440	467½	481½	485	522½	550	619	688	756	825	894	963	1100	1238	1375
325	271	298	325	338½	352	379	406	433½	460½	474	487	514½	541½	609	677	745	815	880	948	1083	1219	1354
330	267	293½	320	333½	347	373½	400	427	453½	467	480	507	533½	600	667	733	800	867	933	1067	1200	1333
340	259	285	310½	323½	336½	362½	388½	414	440	453	466	492	517½	582½	647	712	777	841	906	1035	1165	1294
350	251½	276½	302	314½	327	352	377	402½	427½	440	452½	478	503	566	629	692	754	817	880	1006	1132	1257
360	244½	269	293½	305½	318	342½	366½	301	415½	428	440	464½	489	550	611	672	733	795	856	978	1100	1222
370	238	261½	285½	297½	309½	333	357	380½	404½	416½	428	452	476	535	595	654	714	773	833	951	1070	1189
375	235	258	281½	293½	305	328½	352	375½	399	411	422½	446	469½	528	587	645	704	763	821	939	1056	1173
380	231½	255	278	289½	301	324½	347½	370½	394	405½	417	440	463½	521	579	637	695	753	811	927	1042	1158
390	226	248½	271	282	293½	316	338½	361	383½	395	406½	429	451½	508	564	621	677	733	790	903	1016	1128
400	220	242	264	275	286	308	330	352	374	385	396	418	440	495	550	605	660	715	770	880	990	1100
425	207	228	248½	259	269½	290	310½	331½	352	362½	373	393½	414	466	517½	560½	621	673	725	828	932	1035
450	195½	215	234½	244½	254½	274	293½	313	332½	342½	352	371½	391½	440	489	538	587	636	685	782	880	978
475	185½	204	222½	231½	241	259½	278	296½	315	324½	333½	352	370½	417	463½	509½	556	602	649	741	834	926
500	176	193½	211½	220	229	246½	264	281½	299½	308	317	334½	352	396	440	484	528	572	616	704	792	880

If the brake-arm be made 71⅝ in. long, the values of *W* will be freer of fractions, but the calculation will not be quite so simple as the above. The formula will then be

$$\frac{W\ r.p.m.}{880} = H.P.$$

Table I herewith gives values of pressure or weight, *W* corresponding to different commercial speeds and horse-powers with a 71⅝-in. arm which will enable one to use a brake of this sort without the trouble of calculating results. The most convenient method is to set the scale for the weight corresponding to the speed of the engine or motor and the desired horse-power; then start up and tighten the adjusting screw until the scale beam is lifted from its under stop but *not* thrown against the upper stop. The machine will then be developing the desired horse-power to the friction brake. In using heavy-power brakes of this type, it is necessary to lubricate the brake-shoes in order to obtain a steady frictional co-effi-

TABLE II.—PRONY BRAKE.

Giving weights corresponding to different horse-powers and speeds, for a brake arm 30 ins. long. Numbers in body of table are pounds and ounces.

Rev. per Min.	Horse-power delivered to brake:													
	5	6	7½	8	9	10	12½	15	20	25	30	35	40	45
400	26-4	31-8	39-6	42	47-4	52-8	65-10	78-12	105	131-4	157-8	183-12	210	236-4
410	25-10	30-12	38-7	41	46-2	51-4	64-1	76-14	102-8	128-1	153-11	179-4	204-15	230-8
420	25	30	37-8	40	45	50	62-8	75	100	125	150	175	200	225
425	24-11	29-10	37-1	39-9	44-7	49-7	61-13	74-2	98-13	123-8	148-4	173	197-11	222-6
430	24-7	29-5	36-10	39-1	43-15	48-14	61-1	73-4	97-11	122-2	146-8	170-15	195-6	219-12
440	23-14	28-10	35-13	38-3	43	47-12	59-11	71-10	95-8	119-5	143-3	167-1	190-15	214-11
450	23-5	28	35	37-6	42	46-10	58-6	70	93-5	116-11	140	163-5	186-11	210
460	22-13	27-7	34-4	36-9	41-1	45-10	57-1	68-8	91-5	114-2	137	159-13	182-9	205-7
470	22-6	26-13	33-8	35-12	40-4	44-11	55-14	67	89-6	111-11	134-1	156-6	178-12	201-1
475	22-2	26-9	33-3	35-6	39-13	44-4	55-4	66-5	88-7	110-9	132-11	154-12	176-14	199
480	21-14	26-4	32-13	35	39-6	43-12	54-11	65-10	87-8	109-6	131-4	153-2	175	196-14
490	21-7	25-12	32-3	34-5	38-9	42-14	53-9	64-5	85-12	107-2	128-9	150	171-7	192-14
500	21	25-4	31-8	33-10	37-13	42	52-8	60-3	84	105	126	147	168	189
510	20-10	24-12	30-14	32-15	37-1	41-3	51-8	61-12	82-6	103	123-9	144-2	164-12	185-5
520	20-3	24-4	30-5	32-5	36-6	40-7	50-8	60-10	80-13	101	121-3	141-6	161-9	181-12
525	20	24	30	32	36	40	50	60	80	100	120	140	160	180
530	19-13	23-12	29-12	31-12	35-11	39-10	49-8	59-7	79-4	99-1	118-14	138-11	158-8	178-5
540	19-7	23-6	29-3	31-2	35	38-14	48-10	58-5	77-13	97-4	116-11	136-2	155-9	175
550	19-2	22-15	28-10	30-9	34-6	38-3	47-12	57-5	76-6	95-8	114-9	133-11	152-12	171-13
560	18-12	22-8	28-2	30	33-12	37-8	46-14	56-4	75	93-12	112-8	131-4	150	168-12
570	18-7	22-2	27-10	29-8	33-3	36-14	46-1	55-4	73-11	92-5	110-9	129	147-6	165-12
575	18-4	21-15	27-7	29-4	32-14	36-9	45-11	54-13	73-1	91-5	109-9	127-13	146-2	164-6
580	18-2	21-12	27-2	29	32-10	36-4	45-4	54-5	72-7	90-9	108-10	126-12	144-13	162-15
590	17-13	21-6	26-12	28-8	32-1	35-10	44-8	53-7	71-4	89	106-13	124-9	142-6	160-3
600	17-8	21	26-4	28	31-8	35	43-12	52-8	70	87-8	105	122-8	140	157-8
610	17-4	20-11	25-14	27-9	31	34-7	43-1	51-10	68-14	86-1	103-5	120-8	137-11	154-15
620	17	20-5	25-7	27-2	30-8	33-14	42-6	50-13	67-12	84-11	101-10	118-9	135-8	152-7
625	16-13	20-3	25-4	26-14	30-4	33-10	42	50-7	67-4	84	100-13	117-10	134-7	151-4
630	16-11	20	25	26-11	30	33-6	41-11	50	66-11	83-6	100	116-11	133-5	150
640	16-7	19-11	24-10	26-4	29-9	32-13	41-1	49-4	65-10	82-1	98-8	114-14	131-4	147-11
650	16-3	19-6	24-4	25-14	29-1	32-5	40-7	48-8	64-10	80-12	96-15	113-2	129-4	145-6
660	15-15	19-2	23-14	25-8	28-11	31-13	39-13	47-12	63-11	79-9	95-8	111-6	127-4	143-3
670	15-11	18-13	23-8	25-2	28-4	31-6	39-3	47	62-11	78-6	94-1	109-12	125-6	141-1
675	15-9	18-11	23-6	24-14	28	31-2	38-14	46-11	62-4	77-13	93-6	108-14	124-8	140
680	15-7	18-9	23-3	24-12	27-13	30-14	38-10	46-5	61-12	77-4	92-1	108-2	123-8	139
690	15-4	18-4	22-13	24-6	27-7	30-7	38-1	45-11	60-12	76-2	91-5	106-8	121-12	137
700	15	18	22-8	24	27	30	37-8	45	60	75	90	105	120	135
710	14-13	17-12	21-3	23-11	26-10	29-9	37	44-6	59-3	74	88-12	103-8	118-5	133-2
720	14-9	17-8	21-14	23-6	26-4	29-3	36-8	43-12	58-6	72-15	87-8	102-2	116-11	131-4
725	14-8	17-6	21-12	23-3	26-1	29	36-4	43-8	57-15	72-7	86-15	101-6	115-14	130-6
730	14-6	17-4	21-9	23	25-15	28-12	36	43-2	57-9	71-15	86-5	100-11	115-1	129-8
740	14-3	17-1	21-5	22-11	25-9	28-6	35-8	42-9	56-12	71	85-2	99-5	113-8	127-12
750	14	16-13	21	22-7	25-4	28	35	42	56	70	84	98	112	126
760	13-13	16-9	20-12	22-2	24-14	27-11	34-9	41-7	55-4	69-2	82-15	96-12	110-8	124-6
770	13-11	16-6	20-8	21-13	24-9	27-5	34-2	40-1	54-9	68-3	81-13	95-8	109-2	122-12
775	13-9	16-4	20-5	21-11	24-6	27-2	33-14	40-11	54-4	67-12	81-5	94-14	108-7	122
780	13-8	16-3	20-3	21-9	24-4	26-15	33-11	40-6	53-14	67-5	80-12	94-4	107-11	121-8
790	13-5	16	19-15	21-4	23-15	26-9	33-4	39-14	53-3	66-8	79-12	93-1	106-5	119-10
800	13-2	15-12	19-11	21	23-10	26-4	32-13	39-6	52-8	65-10	78-12	91-14	105	118-2
825	12-12	15-4	19-2	20-6	22-15	25-8	31-13	38-3	50-2	63-11	76-6	89-2	101-13	114-9
850	12-6	14-13	18-9	19-12	22-4	24-12	30-2	37-1	49-7	61-12	74-2	86-8	98-13	111-3
875	12	14-7	18	19-4	21-10	24	30	36	48	60	72	84	96	108
900	11-11	14	17-8	18-11	21	23-6	29-3	35	46-11	58-5	70	81-11	93-6	105
925	11-6	13-10	17-1	18-3	20-7	22-12	28-6	34-1	45-7	56-12	68-2	79-8	90-13	102-3
950	11-1	13-4	16-9	17-11	19-14	22-2	27-11	33-3	44-4	55-4	66-5	77-6	88-7	99-8
975	10-12	12-15	16-3	17-4	19-6	21-9	26-15	32-5	43-2	53-14	64-10	75-7	86-3	96-15
1000	10-8	12-10	15-12	16-13	18-15	21	26-4	31-8	42	52-8	63	73-8	84	94-8
1025	10-4	12-5	15-6	16-6	18-7	20-8	25-10	30-12	41	51-4	61-8	71-12	82	92-4
1050	10	12	15	16	18	20	25	30	40	50	60	70	80	90
1075	9-13	11-12	14-11	15-10	17-9	19-9	24-7	29-5	39-1	48-14	58-10	68-6	78-3	87-15
1100	9-9	11-8	14-5	15-5	17-3	19-2	23-14	28-11	38-3	47-12	57-5	66-13	76-6	85-15
1125	9-6	11-4	14	14-15	16-13	18-11	23-6	28	37-6	46-11	56	65-6	74-11	84
1150	9-2	11	13-11	14-10	16-7	18-4	22-13	27-6	36-8	45-11	54-13	63-15	73-1	82-3
1175	8-15	10-12	13-7	14-5	16-2	17-14	22-6	26-13	35-12	44-11	53-10	62-9	71-8	80-7
1200	8-12	10-8	13-2	14	15-12	17-8	21-14	26-4	35	43-12	52-8	61-4	70	78-12
1225	8-9	10-5	12-14	13-12	15-7	17-2	21-7	25-12	34-5	42-14	51-7	60	68-9	77-3
1250	8-7	10	12-10	13-7	15-2	16-13	21	25-4	33-10	42	50-7	58-13	67-4	75-10
1275	8-4	9-14	12-6	13-3	14-13	16-8	20-1	24-12	32-15	41-3	49-7	57-11	65-15	74-2
1300	8-1	9-11	12-2	12-15	14-9	16-3	20-3	24-4	32-5	40-7	48-8	56-9	64-10	72-12
1325	7-15	9-8	11-14	12-11	14-4	15-14	19-13	23-12	31-12	39-10	47-9	55-8	63-7	71-5
1350	7-13	9-5	11-11	12-7	14	15-9	19-7	23-5	31-2	38-14	46-11	54-7	62-4	70
1375	7-10	9-3	11-8	12-4	13-12	15-4	19-2	22-15	30-9	38-3	45-13	53-8	61-2	68-12
1400	7-8	9	11-4	12	13-8	15	18-12	22-8	30	37-8	45	52-8	60	67-8

cient. The easiest way to do this is to pack suet in between the shoes.

For testing motors of moderate power, the modification of the Kapp form of dynamometer brake, indicated by Fig. 5, will be found more convenient of application than the preceding types and fully as satisfactory in results. This comprises a brake pulley 24 inches in diameter and 12 inches wide axially, a band brake with 12 wooden shoes on the face, and a scale beam of the shape shown, hung on knife edges in a bifurcated eye bolt, which is adjustable by means of a hand-wheel nut to vary the friction load. The pulley is provided with a shrouding flange or web around each edge which extends ½ inch above and 2 inches below the rim, converting the interior face into a trough for the retention of cooling water and preventing the brake-shoes from working off the face. The cooling water is fed to the interior of the pulley by means of a pipe, *f*, Fig. 5, and after absorbing heat it is taken from the pulley by the scoop shown on the end of the waste pipe, *d*. The pulley arms are located at one edge, and the rim tapers in thickness from that edge to the free one, as shown by the cross-section, Fig. 6. The pipe, *f*, delivers water at the thick part of the rim and it is thrown to the thin edge by centrifugal force and taken out on that side by the scoop.

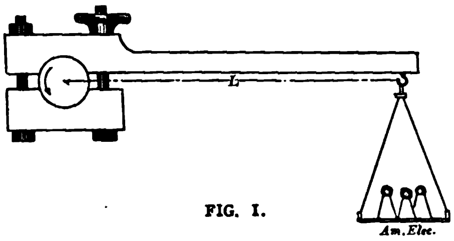

FIG. 1.

The beam from which the scale beam is suspended may be mounted on two A-shaped legs, like the ordinary "horse" used by carpenters, and this fastened to a base to which the motor under test is also bolted. The pulley must, of course, be provided with bushings to adapt it to any size of motor shaft within its range.

The brake shoes should be of hickory, 2½ ins. x 11½ ins. on the face, and one inch thick, bolted to a piece of double leather belting of the best possible quality. The formula for this brake is

$$\frac{W\ r.p.m.}{2100} = H.\ P.,$$

W being the weight deposited in the scale-pan, the beam and pan being accurately balanced by means of the poise, *p*, on the opposite arm from the pan before the brake bend is attached to the scale beam. Table II gives interrelated values of horse-power, speed and weight for this form and size of brake.

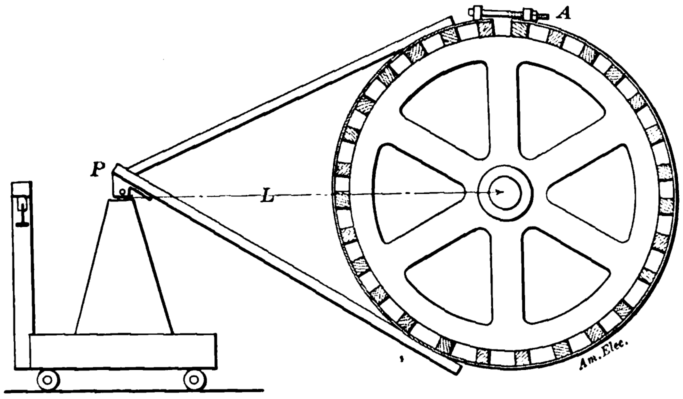

FIG. 3.

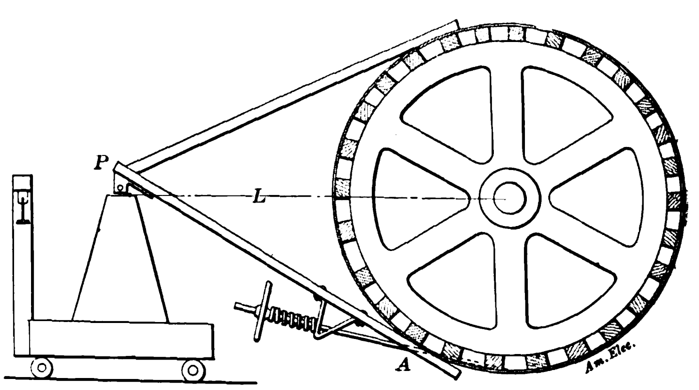

FIG. 4.

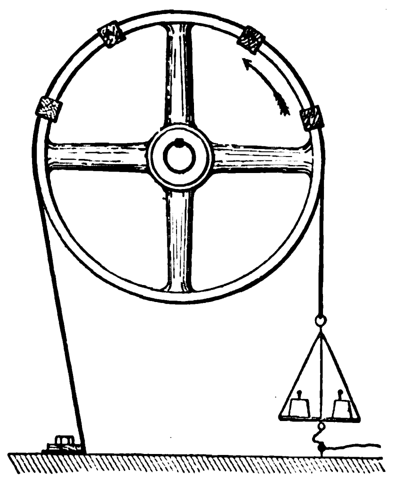

FIG. 2.

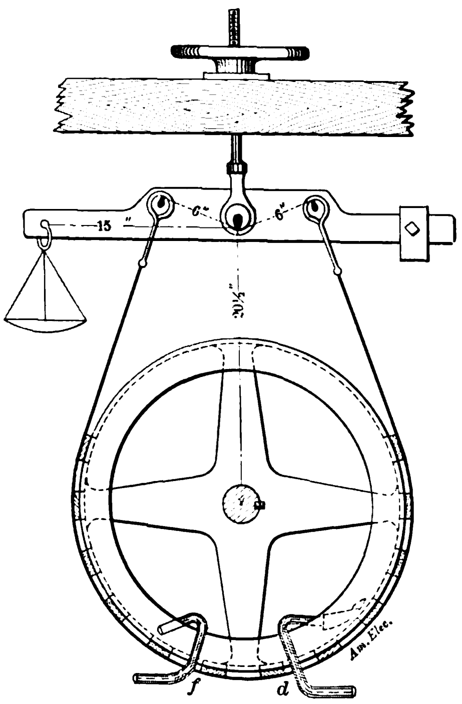

FIG. 5.

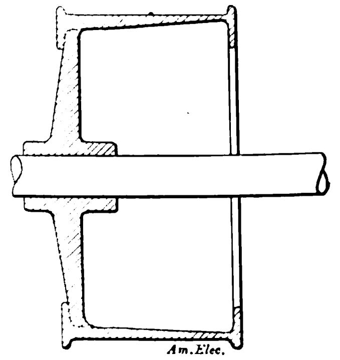

FIG. 6.

Abstracts from Foreign Contemporaries

Electric Conductivity of Filaments of Nernst Lamps.—It is known that pure liquid substances, as a rule, possess rather low electrolytical conductivities; in most cases of electrolytical conduction solutions are therefore present. This is equally true of the solid state, as the metallic oxides of which the filaments of Nernst lamps are made up are always solid solutions of one or more oxides in another; they ought to undergo a most rapid reduction, were the mechanism of their conduction wholly analogous to that exhibited by liquid electrolytes. Now, these filaments are known to stand the passage of direct current for hundreds of hours. If, therefore, their conductivity be really an electrolytic one, there should exist some simultaneous antagonistic process compensating the effect of electrolysis.

A paper recently published by E. Bose in the *Annalen der Physik* deals with this interesting question, the result of the experiments recorded being that the filaments of Nernst lamps really show such an electrolytical conductivity, complicated by a secondary compensating process. The author presumes that, in the case of those metallic oxides, the velocity of migration of the cation is much lower than the one corresponding to the anion, so as to impart a preponderant rôle in the conduction process to the latter, the oxygen ion. The oxygen evolved at the anode rediffuses within the filament towards the cathode, where it oxidizes anew the metal deposited in the pure state, this process being accelerated by the atmospheric oxygen surrounding the filament, and filling its pores. Now, this "residual current," forming, together with the electrolytical migration of the ions, a closed cycle, could be either external or internal, according as it takes place in the ambient air and the air filling the pores (thus giving electrolysis with excellent depolarization), or within the oxide itself, as at high temperatures oxygen is likely to be readily absorbed by the oxide. It even seems as though both phenomena occurred at the same time.

Evacuating the tube surrounding the filament, the author states that the conductivity of the latter gradually increases as the exhaustion augments, its color passing at the same time from brilliant white to a dark red. Investigating closely this phenomenon, the author observes that filaments extinguished in a vacuum will show a dark gray color as the air is allowed to enter again, this coloration being most probably due to a thin metallic stratum. This stratum readily disappears if, instead of allowing the filament to go out, the air is restored immediately. These phenomena clearly show that a more or less rapid reduction of the filament is taking place, the liberated metal being burnt by incandescence in the atmospheric air. This equally results from the fact that, while the current is kept on, the vacuum cannot be increased so far as to cause the appearance of green fluorescence on the walls of the tube, whereas this result is easily arrived at on opening the circuit. This is due to the oxygen evolved by the electrolysis of the filament as the lamp is worked.

On the basis of these results the writer thus explains the alterations of the conductivity in a vacuum: The metal liberated at the cathode, not being wholly burnt, forms rather thin dendrites advancing, within the filament, towards the anode. The more perfect the vacuum the less complete is the oxidation and the further the metal will advance towards the opposite electrode. The filament burning in a vacuum thus forms a system possessing, to a greater or less extent, besides electrolitical, a metallic conductance, whereas in the immediate neighborhood of the anode there exists an often very short section with purely electrolytical conductance.

These facts account for two points known for some time to makers of Nernst lamps: First, the life of the filaments is reduced to a considerable extent by frequent changes of polarity on account of the partial reduction of these oxides, the metal liberated giving rise to internal stress, owing to its changes of volume. Secondly, the filament will burn with less brilliancy in the portions where metal is reduced on account of the increased conductivity. Now, it is known that the efficiency of a lamp increases very rapidly with rise of temperature. The darker parts, accordingly, will lower the efficiency, and the lamps run by alternating current will be more economical than direct-current lamps, the latter undergoing a partial reduction to metal. Moreover, this reduction will deprive the filament of part of its selective emissive power, to which the high efficiency of Nernst lamps is said to be due.

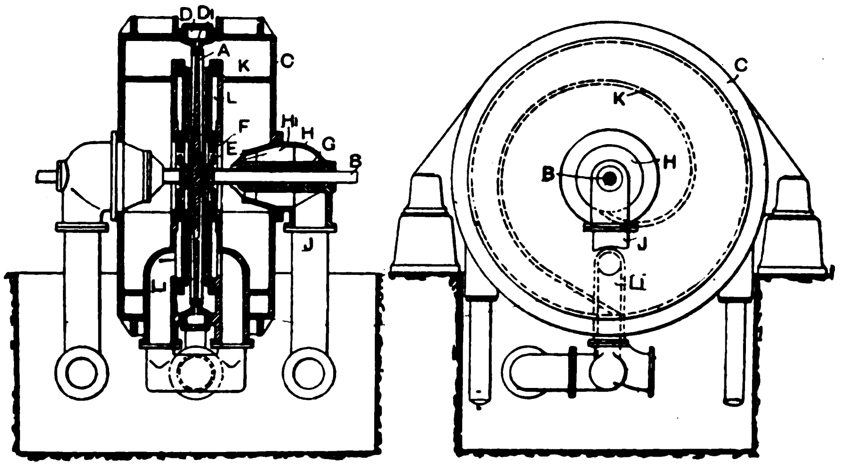

FIG. 1.—CONDENSER FOR STEAM TURBINES.

Condenser for Steam Turbines.—The accompanying illustrations show an arrangement of condenser designed by J. Stumpf, of Berlin, and described in the London *Mechanical Engineer*. The condenser consists of a turbine wheel surrounded by a non-rotatable guiding vane rim, to the buckets of which turbine wheel cooling water is led, so that in case the turbine wheel rotates and the steam to be condensed is led to the same, small water plugs are formed in the channels between the vanes of the guiding vane rim, between which water plugs steam is enclosed. This steam is thus condensed on account of being enclosed between plugs of cooling water. The condenser is advantageously used in connection with steam turbines, in which case the bucket wheel is situated within the turbine casing and fixed to the turbine shaft. Referring to the illustrations, the turbine wheel *A* is situated within the closed casing *C* and fixed to the shaft *B*. Around the turbine wheel *A* is arranged the steam admission channel *D*, from which the steam is led to the turbine wheel through the ports D_1. In the drawing a turbine wheel with double buckets is shown, in which the steam enters in the middle between the two buckets, is divided into two parts by the partitions between these buckets and leaves the turbine wheel on both sides. On both sides of the turbine wheel *A* bucket wheels *E* are fixed to the shaft *B*, and these bucket wheels are surrounded by the non-rotatable guiding vane rims *F*. Each bucket wheel forms, together with its guide vane rim, a condenser in the manner stated above. The steam leaving the turbine wheel *A* flows within the casing *C* to the condensers. This steam will come into contact with the cooling water, especially in the annular space situated between the bucket wheel and the guiding vane rim, and will be condensed between the water plugs arising in the channels of the leading vane rim. The bearings *G* of the shaft *B* are situated in casings *H*. The water which is led to the condensers flows through the casings *H* and thereby keeps the bearings *G* cool. The water is led to the turbine through pipes *J*, and enters the casing *C* through annular openings H_1 situated around the shaft *B*, then flows along the shaft *B*, and enters the bucket wheels *E*. Already while the cooling water passes from the casings *H* to the bucket wheels *E*, the water is in contact with the steam, and will effect a condensing of the same. The bucket wheels *E* provided with cut-outs effecting that also, while the water passes in the wheels *A* in order to get to the buckets of the same, the steam can come in contact with the same and be condensed. On both sides of the turbine wheel spiral-formed partitions *K* are provided, which serve the purpose of leading the steam leaving the turbine wheel to the condensers. From the guide vane rims *F* the cooling water and the condenser water flow into the annular channel *L*, and are led off through pipes L_1.

Automobile Storage Battery Data.—Figures relating to weight, power required and cost of storage battery automobiles were given by L. Jumeau, in a paper at the congress of the French Association for the Advancement of Science. The average consumption of energy is, according to the author, 116 watt hours per ton-mile, so that at an average speed of 12½ miles per hour the power for a vehicle weighing with load one ton figures out to 1,450 watts. The ratio of battery weight to total weight is usually between 25 and 30 per cent; in no case more than 35 per cent for commercial vehicles, inclusive of all accessories, such as trays, connectors and cables, which may weigh as much as one-seventh of the battery proper. For such vehicles, then, the weight of the cells is 604 lbs. per ton, and the weight of the battery complete 700 lbs. per ton. The relation between the weight of the cell to the weight of the electrodes varies with the type of electrodes used. For the different French automobile batteries this ratio varies between 1.33 and 1.6. This ratio is, of course, greater the lighter the electrode and the larger the electrolyte capacity. With a ratio of 1.6 the total weight of the cell is made up as follows: Electrodes, 1; hard rubber cell, .10; electrolyte, .40; various parts, such as separators, covers, etc.,

.10. Accordingly the weight of electrodes for a vehicle weight of one ton is $604 \div 1.6 = 377$ lbs. The specific rate of discharge is therefore $1{,}450 \div 377 = 3.85$ watts per pound, and the current—calculating on a mean pressure of 1.9 volts—about 2 amperes per lb. A table of French batteries of the pasted type indicates that these rates of discharge can be sustained in a five hour discharge, and consequently a mileage of $5 \times 12\frac{1}{2} = 62\frac{1}{2}$ be obtained.

The Sudgen Water-Tube Boiler.—The London *Electrical Review* describes one of the latest forms of water-tube boilers to make its appearance in England; the invention of Thomas Sugden. The "Sugden" boiler, while not departing from well-known general lines, is said to embody improvements of an important character for providing means for more efficient circulation of the water, better fuel combustion and improved furnace arrangements to render the heating surface more effective, one object kept in view being the better prevention of smoke. The boiler is constructed in sections, and straight headers are employed with tubes placed immediately over each other; the baffles are placed horizontally.

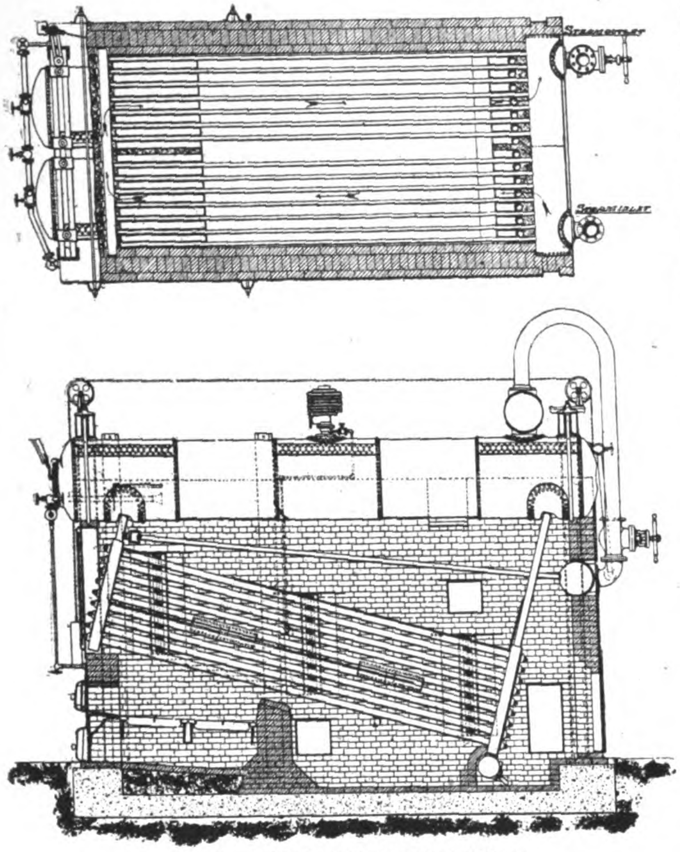

FIG. 2.—SUDGEN WATER-TUBE BOILER.

Water-tube boilers, as hitherto constructed, require approximately about 50 per cent. more heating surface than Lancashire and similar types of internally-fired boilers for the same amount of water evaporated, thus indicating the fact that a given amount of heating surface in a Lancashire boiler is more effective than the same amount of heating surface in a water-tube boiler. For example, a Lancashire boiler, 30 ft. x 8 ft. diameter, has 966 sq. ft. of heating surface; this boiler will evaporate under fair conditions of draught and fuel say about 7,000 lbs. of water per hour. To evaporate this amount in a water-tube boiler at least 1,600 sq. ft. of heating surface is required. The reason for this difference in efficiency of heating surface is, to a large extent, due to the method of abstracting the heat from the furnace. In the case of the Lancashire boiler, an area of only a few square feet of heating surface is presented to the flame immediately over the fire, whereas in a water-tube boiler about one-third of the heating surface of the boiler is placed directly over the fire, the effect of which is to cool the gases below the point of ignition, and in this way it is possible for gases which have not by any means produced their full quantity of heat to pass away into the main flue. Instances have occurred where such gases have become ignited by means of a stray spark, and have burst into flame after passing into the flue, on the way to the chimney.

Water-tube boilers are constructed somewhat after the manner of a surface condenser, and if provision be not made for absorbing the heat gradually, the furnace gases become too quickly chilled. One of the objects aimed at in the design of the "Sugden" boiler is to render the heating surface more effective and to prevent unconsumed gas from passing into the flue. This is provided for in the arrangement of the furnace whereby the gases are made to travel longitudinally over the tubes, that is, in the direction of the length of the tubes. The heating surface is divided into three chambers or compartments, by means of horizontal baffles. The bottom baffle is pierced with a number of slots or openings immediately over the furnace where the fire is hottest. Through these slots a small proportion of the flame and heated gases is allowed to escape direct into the second chamber, the bulk of the gases, it is claimed, passing along the tubes in the first chamber towards the rear end, and thence into the second chamber. Any gas which, in contact with the large amount of heating surface in the first chamber, has been cooled below the point of ignition before combustion, now comes into contact with the numerous flame jets from the first chamber, and is reignited. In this way the gases are more effectually consumed.

A further advantage of the arrangement is that the flow of gases is horizontal. The gases completely envelop the tubes, thus preventing the accumulation of soot on their upper surfaces. Where the gases move in the direction of the tubes there is no useful purpose served by placing the tubes in "stagger." The effect of a straight header is to secure a freer circulation of the water, its course not being impeded by the resistance of a tortuous passage.

As regards smoke prevention, the furnace is so arranged as to admit of the correct principle of firing being adopted, viz., supplying the fresh or green fuel at the front and maintaining a white-hot fire at the rear of the grate. The smoke from the fresh fuel passing over the incandescent fire is ignited and consumed with the air admitted for the purpose. The one and only way of burning smoke effectively is to pass it over the incandescent fire as described, while mixed with the air necessary to ensure its combustion.

Sugden's superheater is shown in the upper part of the illustrations. The chief features of this are straight tubes of uniform length and diameter, no joints in the fire, and no flooding water required during the process of raising steam. The use of flooding water is open to very serious objections owing to damage from neglect to blow off the flooding water before turning on steam to the engines, and to leakage of water through the flooding cock, as well as to incrustation in the tubes, which results from the evaporation of the flooding water, thus rendering the heating surface ineffective and the tubes liable to burn out. Steam from the boiler enters a drum at the rear end of the superheater. This drum is divided into two compartments, one being the inlet and the other the outlet to the superheater. The inlet side communicates with a series of tubes, which convey the steam to the front end of the boiler into a header connected by a similar series of tubes to the second division, that is, to the outlet of the superheater drum, whence the steam passes along to the main steam pipes.

The superheater tubes are arranged as shown to intercept the heat from the flame and furnace gases in such a manner as not to be exposed to the more intense heat immediately over the fire. A relief pipe is provided which discharges the superheated steam into the boiler when steam is first being raised, thus causing steam to circulate through the superheater tubes. This pipe is provided with a valve, which is operated by mechanism connected to the stop valve so as to be fully open when the stop valve is closed, and closed when the stop valve is open.

With respect to the construction of the headers, these, instead of being welded, as usual, are made of solid-drawn steel.

The Electrolytic Recovery of Tin from Scrap.—Dr. H. Mennicke has contributed to recent issues of the *Zeitschrift für Elektrochemie* a useful series of articles upon the electrolytic recovery of tin from tin scrap. According to Dr. Mennicke, Germany possesses seven works operating processes of this character, and in the last year for which figures are obtainable, 30,000 tons of scrap were dealt with by the electrolytic processes.

Germany itself is unable to provide the enormous amount of scrap required, and the supplies of raw material for these works are largely drawn from England, France and Switzerland. The average percentage of tin contained in the scrap is only about 3.0 per cent, but 88 per cent of this can be economically recovered by the electrolytic methods in use, and both the tin, which is obtained as a spongy deposit at the cathodes of the cells, and the iron, after metallurgical treatment, are sold without difficulty to metal merchants. The author discussed at some length the advantages and disadvantages of various electrolytes which have been used for stripping the tin from the scrap by electrolytic action, and recommends the use of a simple alkaline solution of sodium hydrate. This yields a solution of sodium stannate comparatively free from other impurities. The tin can be electrolytically deposited from this solution in the spongy state without risk of contamination by iron. The addition of sodium chloride to the alkaline solution, in order to increase its solvent action, is not approved of by the author, since this addition largely increases the amount of impurity in the electrolyte.

Convention of the Northwestern Electrical Association

The Northwestern Electrical Association held its tenth annual meeting at Milwaukee, Wis., January 21, 22 and 23, with excellent attendance. In his opening address President Irving Lord referred to the unusual prosperity which has been enjoyed during the past year and said that while purchasers of new electrical machinery and supplies had had to pay higher prices than they did three or four years ago, the increased incomes of the central stations had been such that the net proceeds at the end of the year were somewhat larger than for previous years.

A committee appointed at the last convention to consider the question of uniformity of advertising literature presented its report at this meeting. The committee's report pointed out the desirability of adopting uniform methods and sizes for advertising literature, and after referring to the action of the Master Car Builders' Association in adopting standard sizes for pamphlets, catalogues, etc., recommended that this association adopt the following standard sizes: For postal cards, circulars, quotations, etc., 3 ins. x 5 ins.; for catalogues, 4 ins. x 6 ins. and 6 ins. x 9 ins.; for letter paper, specifications, bulletins, circulars and similar material 8½ ins. x 11 ins.; all descriptive circulars to be printed on paper similar in size and thickness to letter paper and issued in bulletin form, the bulletins to be numbered and dated and to have two holes punched five inches apart in the left-hand margin, so that they may be secured in binders. A card index system was suggested for use in conjunction with the bulletins. It was suggested that the cards be made very thin and provide space on which prices may be recorded, the cards to be 3 ins. x 5 ins. in size. The committee further recommended that the manufacturers use business cards of this size so that these might be filed in an ordinary card index file. The report of the committee was adopted later on during the convention, and the committee was continued with instructions to use all possible endeavors to press the matter and secure recognition of the advantages of such a system as that recommended.

Mr. Thomas R. Mercein, secretary of the Association, then read a very interesting history of the organization, which was formally inaugurated ten years ago at Milwaukee. The Association now has about 200 members, many of whom are in states outside of the territory to which the Association is theoretically limited by its name. Mr. Mercein's paper contained several suggestions for the advancement of the Association's interests, and at the conclusion of the paper a committee was appointed to act upon these suggestions.

Prof. A. H. Sabin then read a paper on "Metal Preservation," in which he explained why coatings applied cold, such as paint, were inferior to baked enamel coatings, and described the fundamental processes of applying such an enamel coating. At the close of the paper Mr. Pearce, of Negaunee, Mich., asked what was the best way of obviating rapid deterioration of smoke stacks. Prof. Sabin said that the primary trouble with the lower part of the stack is that no paint or varnish can be applied that will stand a heat of more than 400 degrees Fahr. for any length of time, and in many cases the temperature of the gases is much above this. The deterioration of the upper part of the stack is due, he said, to the sulphur in the coal. This does not affect the paint directly, but all paint is slightly porous, and the sulphurous acid gains access to the iron through the pores.

The morning session of the second day of the convention opened with a call for questions and answers, in response to which Mr. Pearce referred to inequitable taxation to which his plant had been subjected, and asked for suggestions as to methods of correcting this evil. His plant, he said, cost $142,000 when new and the owners would be willing to sell it for $80,000; notwithstanding this, the tax assessor's expert put the tax on gross receipts at a rate corresponding to a plant value of $200,000. After considerable discussion of this question, a committee previously appointed to consider proposed additions to the National Electrical Code of Underwriters' rules, submitted to the Association by the council of the American Institute of Electrical Engineers, reported in favor of the proposed rules without change, and the committee's report was adopted by the convention.

The next paper to be read was one on the subject of "Rates and Methods of Charging," by J. W. Shuster, of the University of Wisconsin. In the paper six methods of charging were discussed, namely, the old flat rate, the straight meter rate, the Wright maximum demand system, the Doherty system of charging, the "Four-C" system, and the double meter rate. The author expressed the opinion that the flat rate had no place in central station economy, some form of meter charging only being permissible. The Wright demand system, he said, gets at the correct basis of charging but embodies the weakness that a very short hour consumer will not use power enough to pay for the demand, or a stand-by, charge, even at the higher rate. Referring to the Doherty and "Four-C" systems, he said that while it is desirable to make a capacity charge, or a charge for readiness to serve, in order to insure the plant from loss on short-hour consumers, this charge should be made as small as possible, so that the number of lamps demanded will be a large proportion of the total number connected up. When there is a question as to what the stand-by charge should include, he advocated making it cover the generating costs and the actual output expenses as far as possible. Referring to the double-meter rate system, in which two rates are charged, one for periods of light load and a higher one for the peak period, he pointed out that while this method has a strong tendency to broaden the peak, it also tends to reduce the maximum output, which is objectionable.

In the discussion which followed the reading of the paper, Mr. Gille expressed the opinion that flat rates were permissible for window lights and sign lamps, advocating the use of time switches to cut out the lights at the proper time or the practice of having them switched out by inspectors. Mr. Lord said he had met this problem satisfactorily by connecting window and sign lights through separate meters and charging a lower rate for this service than for the regular service.

Prof. George D. Shepardson, of the University of Minnesota, then read a paper on "The Economic Value of Testing," in which he emphasized the necessity for making systematic and careful tests of the various pieces of apparatus used around the station. The paper was so comprehensive in character that it cannot be abstracted with justice to it. Prof. Shepardson supplemented his paper by a reference to the question of working hours for central station men. There are opportunities in that branch of work for good men, but the fact that station men have to work from twelve to twenty hours a day, seven days in a week, has caused the better class of technical graduates to go into factories or with construction engineers, rather than into central station operation. He thought this development was unfortunate for the central station interests.

At the afternoon session of this day's proceedings the officers for the ensuing year were elected as follows: President, F. W. Bowen, of Kenosha, Wis.; first vice-president, H. J. Gille, of St. Paul, Minn.; second vice-president, A. M. Barron, of South Bend, Ind.; secretary and treasurer, Thomas R. Mercein, Milwaukee, Wis. Board of directors: S. B. Livermore, Winona, Minn.; T. F. Grover, of Fond du Lac, Wisconsin, and J. H. Harding, of La Porte, Indiana.

The next paper to be read was one on automatic voltage regulators, by H. C. Wirt, of Schenectady, N. Y., who described an interesting new regulator which has just been adopted by the General Electric Company and is to be applied to both direct-current and alternating-current circuits. This regulator controls the e.m.f. of the generator by closing and opening a short-circuit across the terminals of the field rheostat, this operation being made at rates of speed varying from 50 to 800 times a minute; and the effective e.m.f. on the circuit depending upon the rate at which the field rheostat is cut in and out. In the case of an alternating-current machine, the regulator is applied to the field winding of the exciter. The author also described a feeder voltage regulator built by the same company.

Mr. W. D'A. Ryan, of Lynn, Mass., delivered a most interesting lecture on modern illumination, which was illustrated with lantern slides, and in the course of which he displayed a photograph of a chromoscope that he had devised for comparing the appearance of a given material under different kinds of light at the same time. He then proceeded to describe what he termed a "concentric light diffuser," which has been brought out by the General Electric Company for the purpose of reducing contrasts and the effect of the wandering of the arc in enclosed arc lamps. Mr. Ryan also presented some figures showing the number of watts required per square foot of illuminated surface in arc lighting, these figures being deduced by the General Electric Company from experience. The figures are presented in the accompanying table:

WATTS* PER SQUARE FOOT FOR HIGH CLASS ARC LIGHTING.

Building.	Range.	Average Conditions.
Machine shops; high roofs, electrically driven machinery, no belts	.5 to 1	.75
Machine shops; low roofs, belts and other obstructions	.75 to 1.25	1
Hardware and shoe stores	.5 to 1	.75
Department stores; light material, bric-a-brac, etc	.75 to 1.25	1
Department stores; colored material	1 to 1.5	1.25
Mill lighting; plain white goods	.9 to 1.3	1.1
Mill lighting; colored goods, high looms	1.1 to 1.5	1.3
General office; no incandescents	1.25 to 1.75	1.5
Drafting rooms	1.5 to 2	1.75

* Energy based on watts at lamp terminals.

In reply to a question by Mr. Gille as to why the number of square feet for enclosed spaces was made the criterion, instead of the number of cubic feet, Mr. Ryan said that this gave a very satisfactory constant, whereas taking the cubic feet as the basis involved a continuous change.

In accordance with a communicated suggestion from Mr. Henry L. Doherty, who was unable to be present, the Association voted to hold its summer meeting next year at the St. Louis Exposition in connection with the convention of the National Electric Light Association.

SOME RECENT ELECTRICAL PATENTS

Intercommunicating Telephone System.—In most intercommunicating telephone systems thus far devised, it is possible for a person at any one of the stations to listen to a conversation carried on between two other stations by plugging his instrument into the individual circuit over which the other two stations are conversing. One of the simplest and most efficacious means of preventing this is illustrated by Figs. 1 and 2 herewith, and has been patented by Thomas Sloper, of Wilts, and Isaac H. Parsons, of Leicester, England. Instead of connecting both the transmitter and the receiver of each station permanently to the same induction coil or to the same line connections, as is commonly the practice, the receiver is connected to the individual pair of wires corresponding to the station and is not in connection with the transmitter at all. The transmitter and its battery are plugged into the line of the station which is called up, so that the impulse sent out by the transmitter will affect the receiver at the distant station, but not the one at the local station. Therefore, plugging in the local station to any other pair of wires than its own will not enable any one at that station to hear the conversation being carried on over such pair of wires. Referring to the diagrams, Fig. 1 shows an arrangement in which the call-bell of each station is connected across the individual wires corresponding to that station when the hook-switch is down, and when the hook-switch is up the receiver is substituted for the call-bell, and the transmitter circuit is closed. Bridged across the transmitter is a signalling key, and a buzzer, *h*. Depressing the signalling key after the plug has been inserted in the proper jack will of course ring the bell at the distant station connected to the line into whose jack the plug is inserted. For example, the plug, *e*, at station *A* is shown as about to be inserted in the jack, this jack being connected to the individual line wires of station *B*, across which is bridged either the call-bell or the receiver, according to the position of the hook-switch. It will be obvious that with the two plugs inserted in the jacks opposite which they are shown, the transmitter of each station will be in connection with the receiver of the other station when the hook-switches are raised. The function of the buzzer is merely to let the calling station know that the signal has been received by the bell at the other station; the buzzer would not operate unless the bell did. This system is obviously open to the slight objection that the called station cannot reply until it is known which the calling station is, and the local plug is inserted in the jack corresponding to that station. This disadvantage, however, in many cases would be negligible in view of the privacy afforded by the system. Fig. 2 shows a modification of the system, in which all of the bells and all of the signalling keys are connected to a common return wire on one side; each bell is connected on the other side to one of the individual station wires when the hook-switch is down. The object of this arrangement is to prevent a third station from calling up one of two stations, which are in connection with each other. It will be obvious that when a hook-switch is up the signalling circuit of that station is open. Patent No. 718,224.

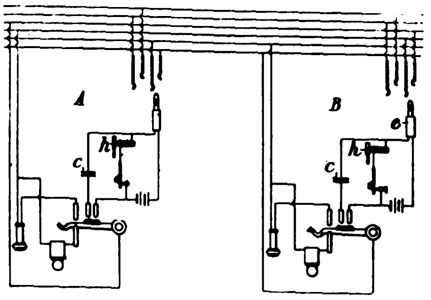

FIG. 1.—INTERCOMMUNICATING TELEPHONE SYSTEM.

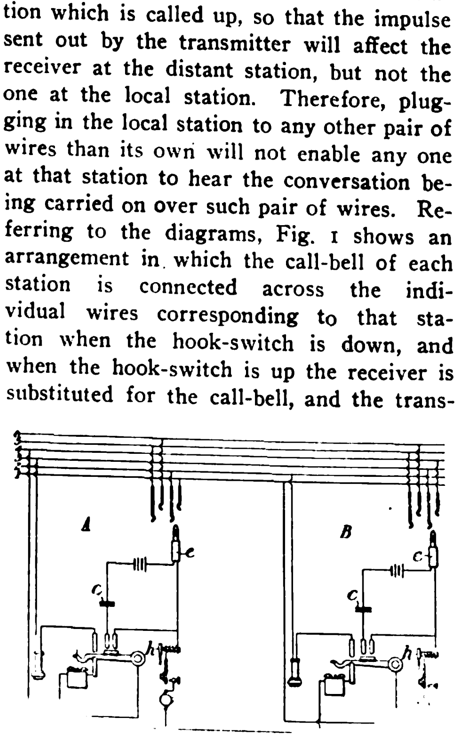

FIG. 2.—INTERCOMMUNICATING TELEPHONE SYSTEM.

Multi-Rate Meter Control.—In the operation of electric lighting or power systems in which two rates are charged for service in order to encourage service during the period of small load, it is frequently the practice to instal at the consumer's station two or more meters having different recording rates. Various methods have been suggested for automatically controllng the connections of such meters so as to connect the proper meter to the circuit at pre-determined changes of the load period; and other methods have been proposed in which this change was not to be made automatically, but effected by means of a control circuit extending from some central point to all of the consumers' premises. A simple system of this sort has been patented by Eustace Oxley, of Lynn, Mass., and is illustrated by Fig. 3 herewith, which shows two meters having inherently different rates of recording and with their series windings connected, of course, with each other. The potential windings, or armature circuits, of the two meters are connected at one end to the special control wire, *4;* the other terminals of the armatures are connected one to the negative wire of the main system and the other to the neutral wire of the system. With the controlling switch at the central station in the upper position, as shown in the diagram, the left-hand meter is active and the armature circuit of the right-hand meter is short-circuited, thus preventing even any effort at creeping. With the switch thrown downward, the relations are reversed, the left-hand armature being short-circuited and the right-hand meter being put into action. Patent No. 717,262.

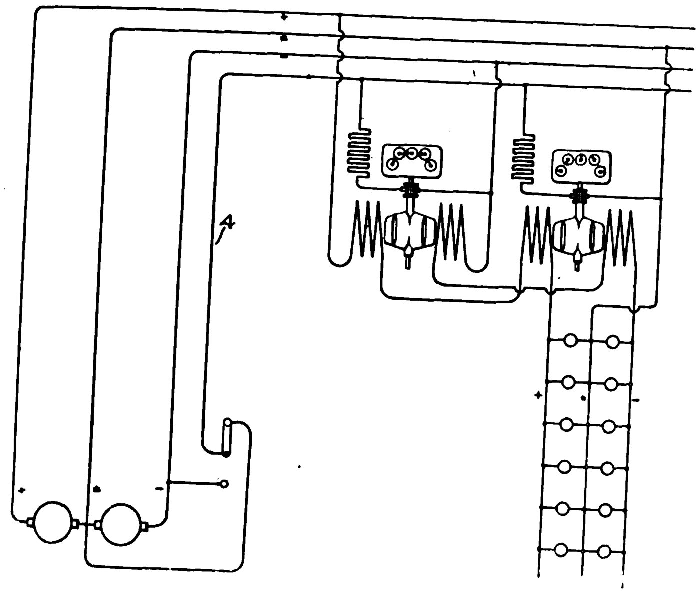

FIG. 3.—MULTI-RATE METER CONTROL.

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NOTES.

Hot Voltage.—According to a rural Ohio paper, two engineers who have been making some changes in an electrical transmission plant are about to engage in the task of replacing the glass insulators on the high-tension lines with porcelain insulators, "the glass being unable to stand the heat of the high voltage which is being carried along these wires."

Digest of Telephone Patents.—A digest of all United States telephone patents issued to December, 1901, compiled by Mr. Jas. T. Allen, will soon be published. The work will be issued in three volumes and comprise several thousand pages of drawings, briefs and letter press. It will also include all of the reissues, designs and trade marks granted during the same period, as well as a complete list of all the references cited, and the interferences and decisions incident to the course of the applications through the Patent Office.

The Wisconsin Telephone Association.—The Independent Telephone Association of Wisconsin will hold its next annual convention at Milwaukee on February 11 and 12. A great many of the prominent telephone men in Wisconsin and the neighboring States will attend the convention and take an active part in the proceedings; in fact, all indications point to an extremely successful meeting. Nearly all of the telephone manufacturers and supply dealers of the Northwest will make exhibits at the meeting. The convention headquarters will be at the Pfister Hotel, and the sessions will be held in the hotel convention hall.

A New Alternating-Current Railway System.—It is reported that the Stanley Electric Manufacturing Company is about to put out a high-tension alternating-current railway system employing motors which will use the current directly without the intermediation of converters or transformers. The e.m.f., frequency and number of phases to be employed have not yet been announced, but it is stated that the power stations will not have to be located nearer than 50 to 75 miles apart. The system to be used is not that of the Ganz Company, but the result of the work done by engineers of the Stanley Company on patents under which the rights to manufacture have been secured from engineers in this country and abroad.

A Splendid Piece of Work.—Mr. Bion J. Arnold has added immeasurably to his already high reputation as a consulting engineer by the preparation of a most exhaustive report on the transportation problem of the City of Chicago, made at the request of the municipal authorities and completed within the astonishingly short length of time of four months. Mr. Arnold's investigation was thorough to the last degree, including even the financial aspect of a single-fare plan for the entire city. The report includes maps and typical cross-sections of proposed systems and stations, and is the most complete one that has ever been made on this or any similar subject. It is so complete, in fact, that if Mr. Arnold's recommendations for a new unified combined surface and subway street railway system should be adopted, the preliminary engineering usually necessary in such cases would not be required here, having been covered in every detail by this report.

Free Lectures.—Several interesting courses of lectures on electricity and physics are in progress under the auspices of the Department of Education of Manhattan Borough, New York City. These lectures are being delivered at several public halls and are entirely free. At Cooper Institute, lectures were delivered by Prof. E. R. von Nardroff on January 7, 14, 21 and 28, and these lectures will be continued on every Wednesday in February. The subjects already covered were Magnetism, Electricity at Rest, Chemical Effects of Electricity, and Heating Effects of Electricity. The February course will be devoted to magnetic effects and inductive effects of electricity and to cathode, Röntgen, radium and electromagnetic waves. Prof. von Nardroff will deliver the same lectures on each Saturday night in February at the American Museum of Natural History, Seventy-seventh Street and Central Park West. At Judson Memorial Hall, on Washington Square South, lectures on chemistry and electrochemistry will be delivered by Prof. W. C. Peckham on each Tuesday evening in February. At St. Bartholomew's Lyceum Hall, 205 East Forty-second Street, Prof. John S. McKay is delivering a series of lectures on natural science. These lectures will be continued on each Saturday night in February, and the course will include a discussion of heat motors, steam engines, steam turbines and gas engines. Mr. W. W. Ker is delivering a course of eight lectures on electricity at Columbus Hall, Sixtieth Street near Columbus Avenue, and at the Young Men's Hebrew Association Hall, Ninety-second Street and Lexington Avenue. The lectures at Columbus Hall are delivered on Thursday nights and those at the Y. M. H. A. Hall on Wednesday nights. This course will also extend through the month of February.

The New York Automobile Show.—The annual automobile show given at Madison Square Garden under auspices of the Automobile Club of America and the National Association of Automobile Manufacturers was held January 17 to 24 inclusive. This is the third regular show of the kind and its success and popularity were indicated by the crowd of exhibits as well as the number of visitors and their great desirability to inspect everything new and meritorious on view. On the opening night some 7,000 or 8,000 persons were present, making circulation difficult, and the attendance through the ensuing week was of the most flattering character. The difficulty of providing for all the exhibits was considerable; not only was the large auditorium fully occupied as well as the complete upper box circle, but exhibits overflowed into and filled up both the restaurant room and the basement. The main hall, handsomely decorated and brilliantly lighted by electricity, supplemented by numerous electrical signs, was a brilliant spectacle, and there were several sales of the more expensive machines. Much interest was also evinced in the various industrial types, and the manufacturers who have devoted their attention to these felt very much encouraged at the outcome of their work in the patronage extended to them. Some disappointment has been expressed in electrical circles that the exhibits of electric vehicles were relatively so few, but it should be pointed out that the makers of them are about as numerous as those of steam, and that the great predominance is enjoyed by gasoline, which at the present moment is undoubtedly the chief source of motive power for heavy vehicles of the touring class. It may be also noted in passing that combination vehicles wherein a gasoline engine is used to drive a dynamo for charging batteries and in which the dynamo is driven as a motor by the batteries is a development of considerable interest and importance; and the work of Mr. Knight Neftel, one of several electrical engineers now working in this field, was studied during the week of the show very closely and carefully by automobilists of all kinds.

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CONTENTS.

Electrical Equipment of a Large Department Store, by C. E. Knox 73
Action of a Shunt-wound Motor When Driven by a Series-wound Dynamo, by A. S. McAllister 79
Telephone Engineering, by F. J. Dommerque.. 80
Driving Boiler Feed Pumps, by C. R. James.. 81
A Remarkable Current Converter.......... 81
Electric Control for Elevators, by H. D. James 83
Prony Brakes for Motor Testing.......... 84
Abstracts from Foreign Contemporaries...... 86
Convention of the Northwestern Electrical Association 89
Some Recent Electrical Patents.......... 90
Editorial 92
Construction of a D'Arsonval Galvanometer, by F. W. Cerny 94
Oil and Compound Feeders for Boilers, by J. F. Hobart 95
Three-wire Direct-current Wiring, by P. C. Percy 97
The Care of Induction Motors in a Large Factory, by A. B. Weeks.......... 99
Lessons in Practical Electricity.......... 100
Letters on Practical Subjects.......... 100
Electrical Catechism 103
Queries and Answers 104
Woodward Frictian Water-wheel Governor.... 105
The Westinghouse Electro-Pneumatic Railway Control System 106
S. K. C. Revolving Field Alternators.......... 107
The Peerless Automatic Stoker.......... 108
New Apparatus 109
Dry Battery Tests 112
New Books ....Adv. 57
Obituary ....Adv. 58
Personal ....Adv. 58
Trade Publications ....Adv. 59
Business News ....Adv. 60

Isolated Plant Voltage.

Most readers who thoughtfully peruse our leading article this month will doubtless be inclined to wonder why a plant of the magnitude of this one was installed on the two-wire plan with a circuit e.m.f. of only 110 volts. Pending a more analytical consideration of the case, one's natural inclination would be toward the opinion that, taking into account the necessity for individual control of arc lamps, it would have been better practice to install a three-wire 220-volt plant. Upon indulging in a little of the analytical consideration just mentioned, however, several things develop which modify the initial diagnosis very materially. The only advantage of a three-wire system is the saving in copper in the bus-bars and connections, the dynamo leads and the feeders. The cost of the copper in these parts of the circuits is roughly from 10 to 15 per cent of the cost of the entire electrical plant. The use of the three-wire system would save from 60 to 70 per cent of the copper required in the affected parts of the circuits, as compared with 110-volt distribution, which means a saving of, say, 8 per cent of the total cost of the plant. On the other hand, the cost of the switchboard equipment of switches and instruments would be considerably increased and the cost of the generating equipment would also be increased, the aggregate increase in these directions amounting to at least 5 or 6 per cent of the total cost of the existing plant. So it is very doubtful if the net saving would in this case have justified the sacrifice in convenience and flexibility that would have been entailed by the adoption of the three-wire system of distribution.

This furnishes an excellent illustration of the advantage that would be derived from the adoption of 150 volts as the standard lowest voltage for lighting and power plants, as we suggested in the December, 1902, number. Here is a large isolated plant that is in what might be termed the "doubtful" class as regards the voltage to be used, and there are many others in that class. With 150 volts as the standard low voltage, there could have been no question as to the preferable plan in this case, and the large majority of isolated lighting plants would be freed from the extra complication involved in the three-wire system. No amendment of Underwriters' rules would be entailed by the suggested elevation in voltage standards, as the existing rules for low potential systems apply to all voltages up to 300. In fact, there is but a single drawback to the adoption of 150 to 300 volts, so far as future plants are concerned, and that is the absence of a high-efficiency 150-volt incandescent lamp. That this deficiency would be eliminated promptly upon demand is not even a debatable question.

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Driving Boiler Feed Pumps.

An interesting suggestion as to the operation of boiler feed pumps is made in an article on this subject which appears on another page. This is to the effect that a triplex pump be driven at constant speed by an electric motor or other power source of good efficiency, and each of the three cylinders be by-passed individually. Opening wide the by-pass of one cylinder then would put that one out of commission, leaving two-thirds of the total pumping rate effective, and so on. But Mr. James' suggestion that the rate of pumping be adjusted by throttling the by-passes more or less is not good advice. So long as one of the cylinders is supplying any water to the boiler, it is not only delivering water against the pressure of the boiler in the feed pipe, but against an equal pressure in the by-pass, the pressure there being due to the throttling. Until the pressure in the by-pass approximately equals the boiler pressure, no water will be delivered to the boiler. The argument, so often advanced, that partial throttling of a by-pass so as to deliver to the boiler only a part of the maximum pump capacity will entail an expenditure of power approximately proportional to the quantity of feed-water delivered per unit of time is a fallacy.

It is true, however, that by by-passing one or two cylinders of a triplex pump with a passage of ample area, the delivery of the pump may be reduced with a saving of almost a proportional amount of power, and to that extent the suggestion is valuable. This leads naturally to the further suggestion that all of the requirements of ordinary boiler room practice might be met economically by means of a triplex pump provided with a by-pass on each cylinder and driven by a double-commutator motor, or, if only alternating current were available, by an induction motor having two combinations of field windings whereby the number of effective poles might be changed in the ratio of 1 to 2. This would give the pumping outfit six rates of delivery, two at maximum efficiency and four at very nearly maximum efficiency. A simple throw-over switch only would be required for controlling the motor speed, giving full speed in one position and precisely half speed in the other. It would be advisable to arrange the by-passes so that the fireman could not throttle them—that is, so that he would be unable to graduate the opening of the by-pass valve, but could only open it wide or close it entirely.

The Elevated Railway Trouble.

One development of the wretched fiasco in the operation of the electric trains of the Manhattan Elevated Railway system during the month of December, to which we referred last month, has been the circulation of reports to the effect that the trouble was entirely due to inherent deficiencies in the electrical system. Persons who appear to have excellent reasons for desiring to discredit heavy-duty electric traction, or the third-rail method, or both, have even caused to be cabled to Europe reports of such a character as to give the impression that electric traction on the elevated roads here is a failure. It was natural to expect that lay observers might entertain this opinion for a while, not being qualified to analyze the recent trouble and differentiate failure to utilize electric traction intelligently from failure of electric traction under proper management.

Now that reason has had opportunity to displace hasty conclusions, it is scarcely necessary to tell even a layman that the Manhattan's problem, so far as the third-rail system is concerned, is solely that of keeping the conductor rail electrically clean. As we pointed out last month, the only serious error in engineering judgment that has thus far developed in connection with the Manhattan equipment consisted in placing the guard timbers so close to the conductor rail as to form a long pocket from which the removal of snow and debris, by any such means as scrapers, brushes, etc., would be difficult. This oversight, however, had no bearing upon the recent service collapse, which was due to sleet on the face of the conductor rail and to the absence of scrapers or other means of removing the sleet. The trouble would have developed precisely as it did had there been no guard timbers and therefore no pocket, notwithstanding the recent contrary intimation by the New York *Times,* which paused in its scientific investigation of alternating-current possibilities long enough to distort the tenor and bearing of our remarks of last month in order to make an opportunity to indulge in patronizing comment upon them.

The service on the Manhattan system has improved conspicuously since January 1 under the stimulus of peremptory orders from the State Board of Railroad Commissioners, itself stung into unwonted activity by public criticism and forced by perfectly frank and vigorous prods from the New York Merchants' Association to get out of its political rut of complacent disregard of shortcomings on the part of railway companies. Despite the reiteration of the claim that no more trains could be operated on the present elevated structure, more trains, even during rush hours, have been operated recently than heretofore, or else a large proportion of the former passengers have died or moved to other localities. The service on the whole during the past thirty days has been so much better than for months previous as to excite apprehension concerning the lasting qualities of the improvement.

Laying Out Armature Windings.

We confess to being at a loss to account for the persistence of the old custom of considering the single conductors or groups of conductors in selecting or determining the "scheme" of a drum armature winding. Where a coil or element of a bar winding comprises two bars and separate connectors that are attached to the ends of the bars in the process of assembling, there may be practical reasons for considering the number of bars and the front and back pitches in terms of bars. But it is not at all necessary to design the winding on the basis of pitch in terms of conductors, or even to consider the pitch at the back end of the armature. Every drum winding consists of coils (or elements, if one's sense of accuracy is offended by applying the term "coil" to a simple loop open at one end), each including two conductors (in the inductive sense) or some multiple of two. Neither the number of paths or circuits through the winding nor the number of wires connected in series in each circuit is affected by the number of core teeth embraced by the coil, which corresponds to the back pitch of the winding. These characteristics are controlled entirely by the number of turns per coil and the relative location of the two terminals of each coil at the commutator; the number of coils, of course, affects the commutator connection to a great extent. And in practice it is simpler and vastly more convenient to consider the coils instead of the conductors, and the connecting pitch in commutator segments instead of in armature conductors. This conclusion is not academic, but is the result of actual experience in the use of both methods.

Working on the basis of coils instead of conductors is also logical from the standpoint of modern practice in armature construction. With the possible exception of machines of enormous size, an armature coil or element is not now generally composed of three or four pieces of copper jointed at the necessary points, but of a single strip bent into the desired shape. In such cases nothing is to be gained by operating a winding department in the old way and dealing with two or three pitches in the winding. Even if an occasional giant be built with jointed coils or elements, it is much easier for a winder to consider the completed element as a unit than, on the other basis, to regard a coil as being so many conductors grouped by means of end connectors having certain pitches. Hence there appears to be small excuse for adhering to the old criterions regarding the characteristics of an armature winding, even in shops, and none at all in text books and engineering offices.

Compressed Air as a Cleaner.

The beneficent results of keeping electrical or other particularly vulnerable machines clean are very generally realized, but the flexibility and efficacy of compressed air as a cleaner of such machines are not appreciated as universally as they might be, judging from the relatively limited number of such applications. One, and possibly the chief, advantage derivable from the use of compressed air to clean dynamos, motors, etc., is the ability to remove collections of foreign material without touching the parts of a machine on which they are lodged. By no other means is it possible to remove oil-soaked copper or carbon dust, for example, without either wiping or scraping the coated part. Perfect cleaning by wiping is almost impossible, to say nothing of the liability of making matters worse by the use of dirty waste or pieces of cloth; the serious objection to the scraping process is obvious. Another advantage of a compressed air cleaning system is that an outlet may be (and usually is) provided near each piece of machinery or apparatus, so that in many cases each one can be at least partially cleaned while in operation. In the worst cases, except those of enclosed machines, a shut-down of only very short duration is necessary for effecting complete cleaning.

In the application of compressed air under discussion, however, the greatest care must be taken in order to prevent grit, dust or similar material from being drawn into the system by the pump. A blast of compressed air containing any such material will, of course, wreak havoc with the surface against which it is directed. Since this may be readily obviated by simple precautions, it can scarcely be regarded as a practical objection to the use of compressed air for cleaning purposes.

CONSTRUCTION OF A D'ARSONVAL MIRROR GALVANOMETER.

BY F. W. CERNY.

The accompanying sketches illustrate a self-adjusting D'Arsonval galvanometer that has been built by the writer, the main features of which have been taken from one that was imported from Paris and made by Ducretet. The case is of ¼-in. oak, 13 ins. long, 3 ins. wide, and 1¾ ins. deep. The block from which it is suspended measures 2½ ins. x 3 ins. x 1½ ins. To the back of this block a piece of brass is fastened by screws and serves to hang the suspension block of the instrument on the wall, ready for use. No leveling is required, since the galvanometer is hung in gimbals, *G*, and will adjust itself to a vertical position.

The field of force is provided by two magnets, *M*, *M*, from a telephone generator; their like poles are butted together and are provided with soft iron pole-pieces made from ⅜-inch bar iron, the inner faces of which are slightly rounded at the corners.

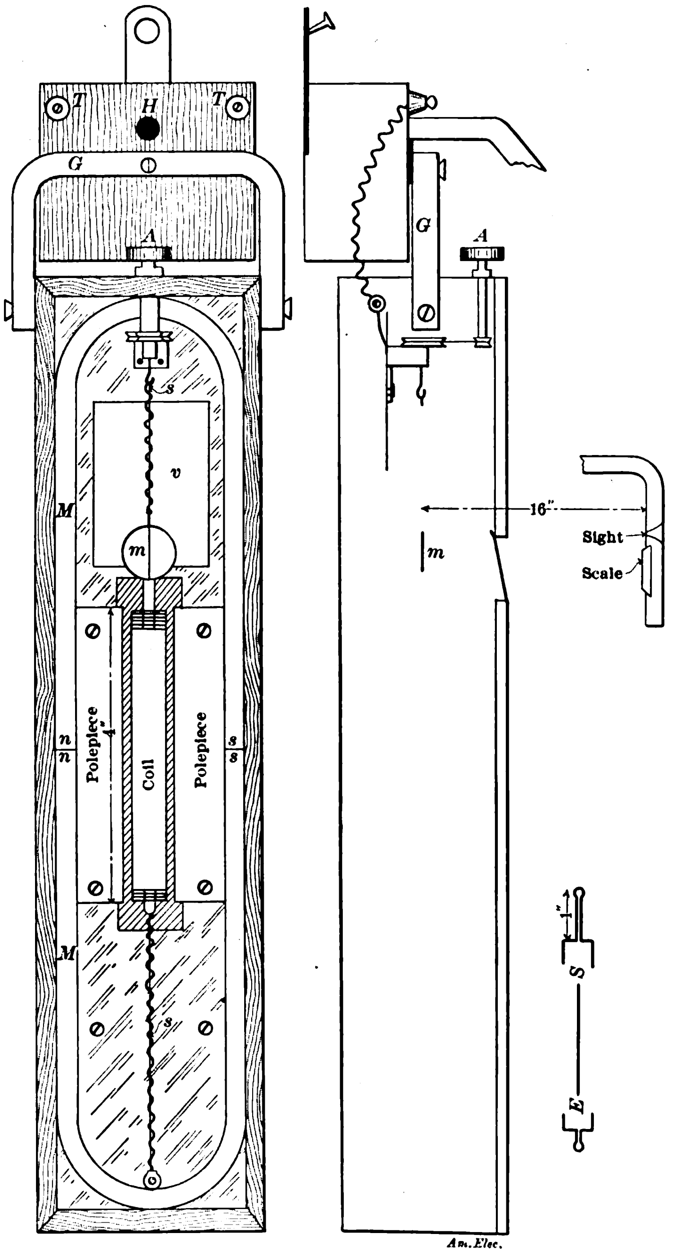

FIG. 1.—D'ARSONVAL MIRROR GALVANOMETER.—FIG. 2.

The pole-pieces are fastened to a piece of wood ½ inch thick and cut to fit snugly inside the magnets. This piece of wood has a channel cut in it to give the coil space enough to swing; above the pole-pieces it is tapered from the middle to the edges to make room for the vane, *v*, to swing. This vane is a piece of thin mica cemented to the back of the mirror, and acts as a damper.

The coil is wound on a very light shuttle, ⅜ ins. x ⅜ ins. x 4 ins. If carefully wound with No. 40 single silk-covered magnet wire it will have a resistance of 1,000 ohms. Two pieces of thin copper are bent to the shapes shown at *E*, *S*, Fig. 2, and these are fastened to the ends of the coil by silk thread. The upper one is made one inch long in order to enable it to carry the mirror. The coil is suspended as follows: Take two pieces of No. 40 wire and heat them sufficiently to burn off the insulation, then coil each piece into a spiral around a piece of No. 18 wire, making each spiral about an inch long. Tie a piece of very fine silk thread to the end piece of the coil and by use of a needle pass the thread through the spiral; now tie the thread to a little hook of No. 26 copper wire in the end of the adjusting spindle and fasten one end of the spiral to the hook and the other end to the end piece of the coil, which must also have one end of the coil electrically connected to it. The lower suspension is made in the same way, except that it terminates in a small spiral of No. 30 brass wire soldered to a piece of copper, as shown in Fig. 1. This brass spiral serves to put a little tension on the suspensions.

In Fig. 2 is shown the arrangement of the adjusting screw, *A*; the two little pulleys on the suspension spindle and the adjusting screw are belted by a stout thread. The mirror, *m*, is made as follows: With a pair of tinner's shears a piece of glass is cut into a ⅜-in. or ½-in. disc; by keeping the shears and glass under water this can be easily done. Then scratch a line across the middle of the disc with a sharp cornered file. Take a piece of tin foil a little larger than the glass and cover it with mercury, then clean the glass thoroughly and put the scratched side down on the tin foil, sliding it around and pushing the surplus mercury off. After the mercury and foil form a hard amalgam the back can be covered with a large drop of thin shellac. Melt a little sealing wax on a piece of mica and lay the silvered side of the mirror on it; after the wax hardens this can be fastened to the upper end piece, *S*, of the coil.

Fig. 3 shows the arm that supports the scale and takes the place of the usual telescope. This arm is made of a piece of No. 1 copper wire bent to such shape that the scale is in the plane of the mirror. Above the scale a tapering hole is bored which serves as a sight. By adjusting the mirror until the reflection of the zero of the scale is in line with the scratch on the mirror the instrument is ready for use. The scratch on the mirror takes the place of the cross-hair in a telescope. With the scale 16 inches from the mirror, 1-16-inch scale divisions can be read very closely.

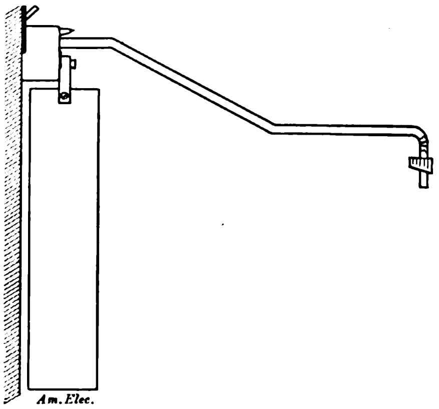

FIG. 3.—GALVANOMETER SCALE ARM.

This galvanometer has a sensibility of 12 megohms, and if the scale be divided into 1-32 inch it will be 24 megohms. When used by the zero method or with a bridge, the scale need not be more than 4 inches long. It makes a good workshop instrument and will stand very rough usage. Vibration affects it but little and it can be used in the dynamo room. If carried with the back down the suspension will not be injured and it is quite portable. All that is required to put it in service is a nail driven in the wall at a suitable height.

Anyone familiar with the use of common tools can make the instrument. If one chooses to buy the magnets as well as the wire, the total cost will be about $3, and the galvanometer will give results that will equal or even surpass some $30 instruments.

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The Power of Marconi's Apparatus.—An idea of the extraordinary power that is used at Marconi's Table Head station for transmitting messages across the Atlantic is given by Dr. Parkin. He says the apparatus is of such remarkable power that the sound, as each letter is transmitted, is so great in volume that it is necessary to use cotton as a protection for the ear-drums. He compares the sending of a message to a miniature thunderstorm. A spark, fully half an inch in width, is shot out upon the air when the key is pressed.

OIL AND COMPOUND FEEDERS FOR BOILERS.

BY JAMES F. HOBART.

It used to be the practice of men who were rated as good engineers to open a steam boiler, drop in a gallon of kerosene oil or a bucket of sal-soda, close up the boiler again, and run for three or four weeks, when the same performance would be repeated. It seems strange that boilers would stand this sort of treatment, but stand it they did, and scale formation was prevented at that. Now-a-days, the engineer who has to use a scale preventative in a boiler does not resort to such allopathic treatment. He wants a device that will introduce the medicine slowly and evenly. Instead of a bucketful once a month a drop or two every few minutes must be provided.

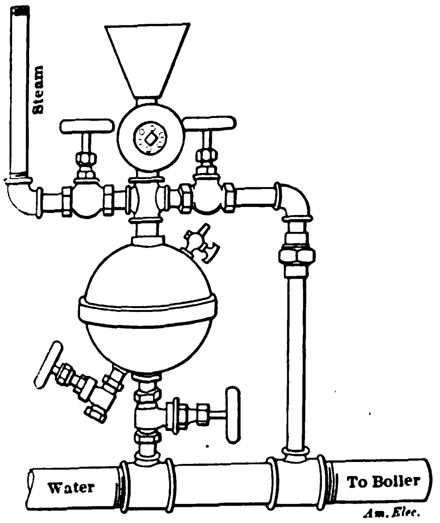

FIG. 1.

Numerous appliances for feeding oil to boilers have been provided, the chief forms of which are here discussed. Fig. 1 illustrates a device which will handle either oil or any of the various so-called "compounds" which comprise the *materia medica* of the boiler doctor. The device may be used either as an injector with steam, or as a vessel from which a graduated quantity is delivered directly into the feed pipe by gravity. When steam is used the globe is filled with oil or "compound" and the two upper valves are opened, all the others being closed. Condensation of steam in the pipe causes water to run into the globe and displace its contents, which are forced slowly into the feed pipe shown at the bottom of the engraving. When the device is used without steam, after filling the globe the bottom valve and the right-hand top one are opened, all the others being closed. This apparatus is known as the Victor boiler compound feeder, and made by the Leavitt Machine Company, Orange, Mass.

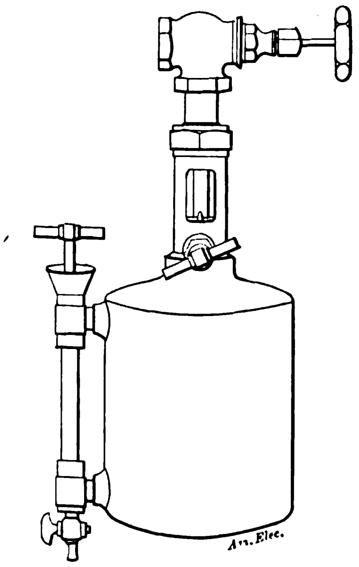

FIG. 2.

Fig. 2 shows one of the sight-feed variety of oil feeders. It is of very simple construction, consisting of an iron tank for containing a supply of oil, a gauge glass that shows the height of oil and water in the tank, and a sight-feed apparatus in the pipe above the tank.

The apparatus is attached directly to the boiler water-feed pipe, through which there is an upward flow of water, and a portion of the water gravitates through the sight-feed pipe and to the bottom of the oil vessel through a passage provided for that purpose. The oil thus displaced flows through a regulating valve, passes through the sight feed device and rises through the angle valve to the feed pipe to the boiler. The oil fed a little at a time in this manner seems to mix better with the water and surround all particles of foreign matter with a film of oil, thereby preventing such matter from adhering to the boiler shell or tubes. The matter thus enveloped in oil finally falls to the bottom of the boiler, in the coolest part (which is in the rear) near the blow-off pipe, whence it may be readily blown out of the boiler. This oil feeder is made by W. H. Ramsdell, Lowell, Mass.

An oil feeder which is very similar in action is shown by Fig. 3. In this feeder the oil is cut off, without affecting the rate of feed adjustment, by means of the valve *A*, in the main boiler feed pipe, so that the feeder may be removed from the pipe. The water of condensation flows through the pipe and valve, *B*, direct into the oil chamber, whence it is discharged through the valve, *E*, after the supply of oil has all been forced into the boiler. The valve *C* is really a plug which closes the filling hole of the oil tank. The regulating valve *D* has a capacity ranging from one to 100 drops a minute, and discharges through the sight-feed glass shown immediately above it. This cut is made by The Sims Company, Erie Pa.

Seman's oil feeder, shown by Fig. 4, is intended to work automatically, feeding the oil a drop at a time, but to depend upon the suction of the feed pump for its motive power. The oil is thus fed through the feed pump, thereby keeping that apparatus in easy working order, and the pipes free from rust or sediment. The condensing chamber *J* is connected to the discharge pipe of the pump (it may be connected to a steam pipe and the cup used in the ordinary manner); a ⅛-inch pipe is connected to the valve *C* and extends to the bottom of the oil tank. Another piece of the same size of pipe is connected to the valve *A* and carried to the top of the tank. When the apparatus is to be started all the valves are closed except the valve C, which is opened slightly, permitting water to enter the bottom of the tank. Then the valve *G* is opened a little and finally the valve *A*, which allows the oil to pass through the pipe leading from that valve and finally appear at the sight-feed glass *B*, from which the suction takes the oil to the feed pump and thence to the boilers. A number of pumps can be supplied from one tank by simply attaching another sight-feed device to the tank for each pump. This apparatus was patented in 1897 by W. A. Semans, Noblesville, Ind.

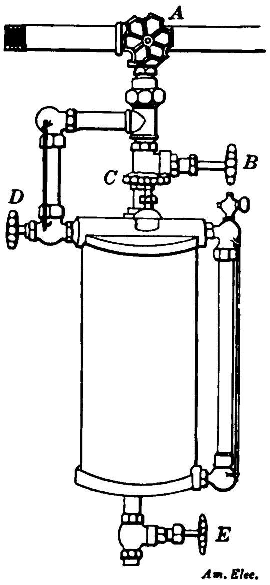

FIG. 3.

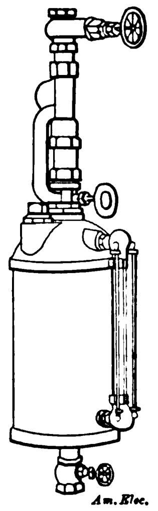

FIG. 6.

A compound-feeding device of decidedly novel construction, made by the L. Blatz Brass Works, Chicago, is shown by Fig. 5. The larger tank, which contains usually about three gallons of compound, is placed below an oil-trap tank, at the right of which is a sight-feed glass which also contains oil. The pipe at the left is connected with the discharge pipe and the plug shown underneath it is for filling the large tank with compound. Water from the pump is forced through the valves at the left, above, and from them passes through the oil sight-feed tube at the right to a regulated sight-feed, after which it passes into the tank,

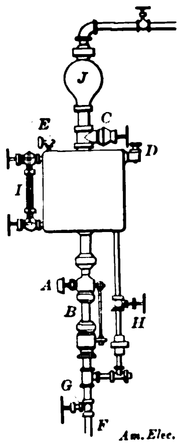

FIG. 4.

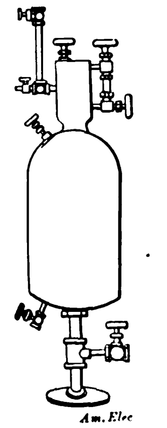

FIG. 5.

forcing the compound out through the connection at the bottom, the amount of compound that is displaced depending upon the quantity of water admitted through the sight-feed tube.

Another sight-feed device of the injector type is represented by Fig. 6. This apparatus is connected to the feed pipe by a single connection, and an individual feeder is intended to be attached to the feed pipe of each boiler, rather than to attach one to the pump or to the main feed pipe. Although this is classed by the manufacturers as an "injector oil feeder," it seems to me more properly to be a displacement device similar in action to those shown by Figs. 2 and 3. Like them, it feeds by the displacement of the oil in the tank, drop by drop, by an equal amount of water which enters from the feed pipe. A feature of this apparatus is an automatic check valve which closes instantly in case a gauge glass breaks. There is also a very simple device for removing a broken glass and for replacing the old glass with a new one. This feeder is manufactured by P. A. Clum & Co., Rochester, N. Y.

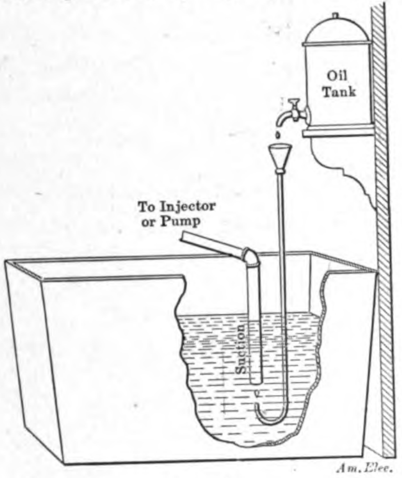

FIG. 7.

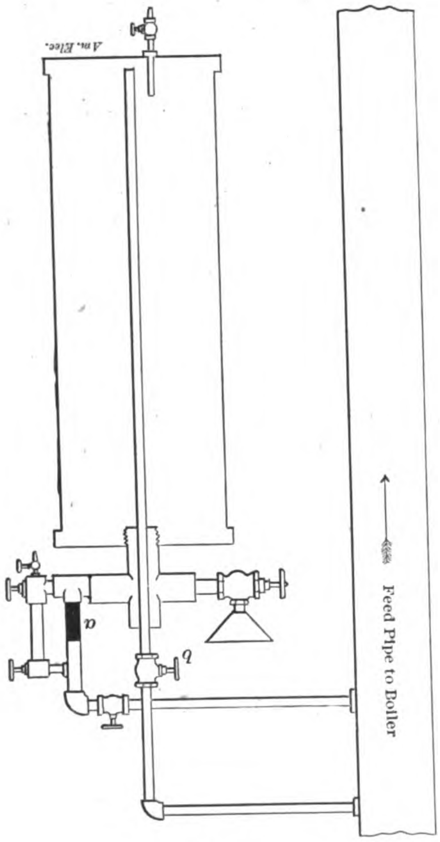

FIG. 10.

Quite a number of very good "home-made" oil feeders have been devised, among which those illustrated by Figs. 7 to 12 inclusive are fairly representative. Fig. 7 represents an arrangement of extreme simplicity, comprising an inverted syphon placed in the water tank directly underneath the end of the suction pipe. When a drop of oil is forced out of the pipe by the pressure of the column of oil in the long leg of the syphon it rises directly into the end of the suction pipe and is carried to the boiler through the pump or injector. The rate of feed is very easily controlled by the valve of the oil tank, and the sight feed is of the plainest kind imaginable.

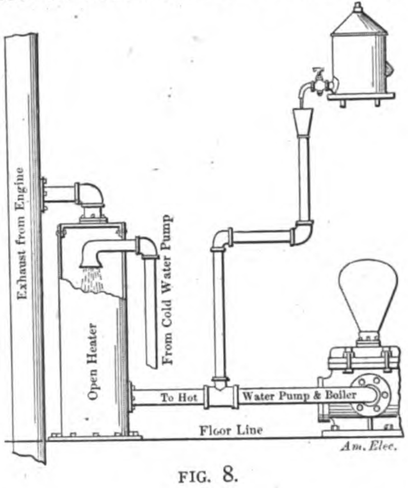

FIG. 8.

Another home-made piece of apparatus, shown by Fig. 8, is practically the same arrangement, except that the oil is forced by gravity directly into the suction pipe, instead of into the tank or open heater. A tee is put in the suction pipe close to the heater, and the oil is dropped directly from the oil-can into a pipe connecting with the tee mentioned.

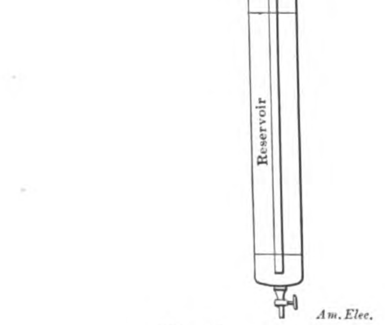

FIG. 11.

Fig. 9 is an elaboration of the simple gravity feed, the connection from the oil tank being taken through a nozzle enclosed in a glass tube through which the oil drops. The tank is made of a bit of 4-inch steam pipe, the black portion of the pipe showing where it is plugged so as to **force** the oil around through the sight-feed apparatus. The angle valve is, of course, for regulation. The pipe, *1*, is to be attached directly to the water-supply pipe before it enters the pump or ejector; there will be no impairment of the suction vacuum, as the sight-feed glass makes the arrangement air-tight.

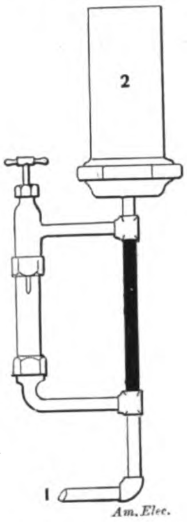

FIG. 9.

A double-connection sight-feed displacement feeder was the result of one engineer's ambition, as shown by Fig. 10. This device is also made of pipe and fittings, the tank being four inch steam pipe about 12 inches long. This feeder possesses all the functions of the "store" appliances illustrated at the beginning of this article. The apparatus has a plugged pipe, *a*, for supporting the sight-feed tube, and the oil-filling arrangement is complete in itself. The feed regulation is very simple and is effected by simply throttling down the supply of water which passes to the tank, the valve *b* being used for this purpose.

A similar device is illustrated by Fig. 11, the double connection being used, likewise the gravity displacement method. In this apparatus the tank is made of a capped piece of 2-inch pipe with a water channel of ¼-inch pipe extending nearly to the bottom of it. The sight-feed arrangement was taken from a discarded lubricator of ancient pat-

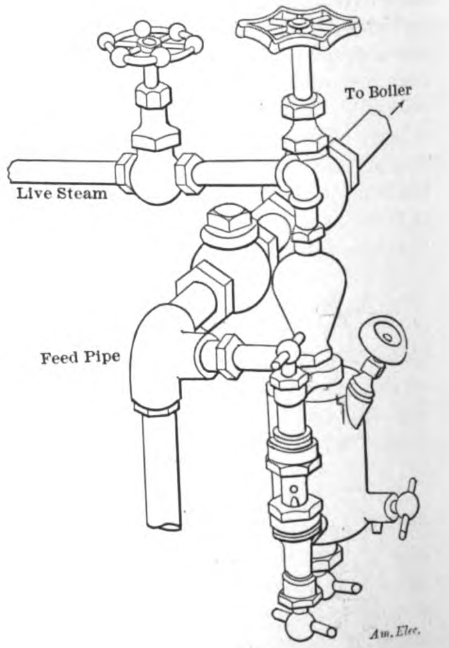

FIG. 12.

tern. The maker of this apparatus states that he used in very bad lime water about one pint of kerosene every ten hours, in a boiler actually developing 80 horse-power.

Fig. 12 shows an arrangement fitted to use live steam, a discarded sight-feed cylinder lubricator being rigged up for the purpose. In this arrangement the oil is forced into the water pipe through an up-sight-feed tube, the steam being used not only to equalize the pressure in the feeder but to furnish water of condensation to force out the oil by displacement. The arrangement is so plainly depicted in the illustration that a further description would be superfluous. In this instance, about one gill of crude oil in 10 hours was used for every 25 horse-power developed by the boiler.

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THREE-WIRE DIRECT-CURRENT WIRING.

BY P. C. PERCY.

In all interior conduit work, and in most inside open work, the main feeders of an installation supplied from a three-wire source are put in on the three-wire plan and the sub-feeders and distributing mains are two-wire, except when this construction entails the use of unwieldy sizes of wire. The "lay-out" of two-wire sub-feeders and mains must be such that under normal operating conditions the total load is divided as nearly as possible into two equal parts, one connected on each side of the neutral post of the main entrance cut-out (or the neutral bus-bar of the switchboard, in an isolated plant). In order to accomplish this, the load on each side of the neutral wire of each feeder of the installation must be as nearly equal as possible. Thus, in Fig. 1 herewith, the positive outer wire of the feeder carries the current required by 31 lamps (all those connected between the neutral wire and the positive wire), while the other outer wire carries the current for 34 lamps; the neutral wire, of course, carries the difference—current for 3 lamps.

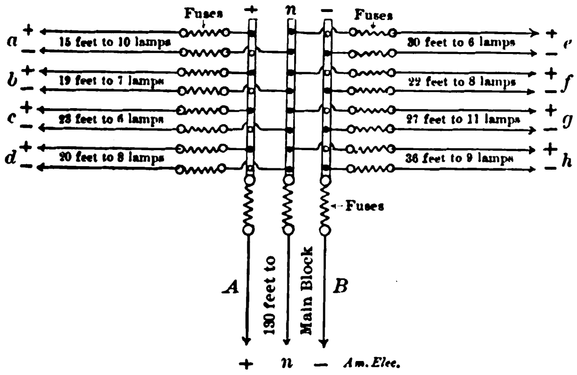

FIG. I.

TABLE II.

For 220-volt incandescent wiring; three-wire distribution.
Numbers in body of table are lamp-feet capacity of the outer wires.
Table computed for 3½-watt 16-c.p. lamps.

Wire Sizes.	Drop in percentage of 220 Volts:						
	½%	¾%	1%	1¼%	1½%	1¾%	2%
0000	43,215	64,820	86,430	108,040	129,645	151,250	172,860
000	34,330	51,500	68,660	85,820	102,990	120,160	137,320
00	27,210	40,815	54,420	68,025	81,630	95,235	108,840
0	21,570	32,355	43,140	53,925	64,710	75,495	86,280
1	17,055	25,580	34,110	42,635	51,165	59,690	68,220
2	13,590	20,390	27,185	33,980	40,775	47,575	54,370
3	10,705	16,060	21,415	26,765	32,120	37,475	42,830
4	8,495	12,745	16,995	21,240	25,490	29,740	33,990
5	6,765	10,145	13,530	16,910	20,295	23,675	27,060
6	5,360	8,040	10,720	13,400	16,080	18,760	21,440
8	3,345	5,015	6,690	8,360	10,035	11,705	13,380
10	2,125	3,185	4,250	5,310	6,375	7,435	8,500
12	1,335	2,005	2,675	3,345	4,015	4,685	5,350
14	835	1,255	1,670	2,090	2,505	2,925	3,340

TABLE I.

Showing the number of 16-c.p. lamps that each standard size of wire may carry without violation of the Underwriters' Code.
The voltages are those between the two outer wires of a three-wire system.

Wire Sizes.	Capacity of Rubber-covered Wires.							Capacity of Wires with Weatherproof Insulation.							Wire Sizes.
	Amperes.	3.1-watt		3½-watt		4-watt		Amperes.	3.1-watt.		3½-watt.		4-watt.		
		220 V.	230 V.	220 V.	230 V.	220 V.	230 V.		220 V.	230 V.	220 V.	230 V.	220 V.	230 V.	
0000	210	924	966	825	862	722	754	312	1370	1435	1225	1280	1072	1120	0000
000	177	778	814	695	727	608	636	262	1150	1205	1030	1075	900	941	000
00	150	660	690	589	616	515	539	220	968	1010	864	903	756	790	00
0	127	558	584	498	521	436	456	185	814	851	726	760	636	664	0
1	107	470	492	420	439	367	384	156	686	717	612	640	536	560	1
2	90	395	414	353	369	309	323	131	576	602	514	538	450	470	2
3	76	334	349	298	312	261	273	110	484	506	432	451	378	395	3
4	65	286	299	255	267	223	233	92	404	423	361	377	316	330	4
5	54	237	248	212	221	185	194	77	338	354	302	316	264	276	5
6	46	202	211	180	188	158	165	65	286	299	255	267	223	233	6
8	33	145	151	129	135	113	118	46	202	211	180	188	158	165	8
10	24	105	110	94	98	82	86	32	140	147	125	131	110	115	10
12	17	74	78	66	69	58	61	23	101	105	90	94	79	82	12
14	12	52	55	47	49	41	43	16	70	73	62	65	55	57	14

In calculating the outer wires of a three-wire circuit the neutral wire is disregarded and the outer wires are treated as a two-wire circuit of the overall voltage. In Fig. 1, for example, the feeder wires *A* and *B* would be considered as a two-wire circuit carrying 65 lamps, not of 110 volts but of 220, and of the same efficiency, of course, as that of the lamps actually to be used. Table I shows the maximum number of 16-c.p. lamps, of either low or high voltage, that each standard size of wire, both rubber-covered and weatherproof, is capable of carrying without violating the Underwriters' Rules, when serving as the outers of a three-wire circuit of 200 or 230 volts over all, or as a two-wire circuit of the same voltage. Table II gives the lamp-feet (lamps x feet) for each standard size of wire, with various drops expressed in percentages of 220. It is scarcely necessary to say that these tables do not apply to a three-wire circuit that is operated "break-down" fashion, with the two outers connected together and the neutral wire serving as one side of the resultant two-wire circuit, as indicated in Fig. 2. It may be as well, however, to caution the reader against the application of Table I to any three-wire installations which are intended to be operated at regular intervals on the two-wire plan just mentioned, which is true in many isolated plants. Such circuits must be figured as two-wire installations of one-half the three-wire voltage.

The size of the neutral wire of a three-wire circuit will depend upon the conditions of operation to a great extent. If the installation must occasionally be worked two-wire, then the neutral wire should have a cross-section equal to the combined cross-sections of the two outer wires. This plan is commendable in general for buildings supplied from a central station, for the reason that the wiring will be efficient under every practical set of conditions. It will serve equally well for two-wire operation in emergencies, and for three-wire two-phase or three-phase distribution should the central station ultimately be changed over to either of those alternating-current systems. The expense for the extra copper in the beginning will not be nearly so great as that entailed by a change in the wiring later on should developments require it.

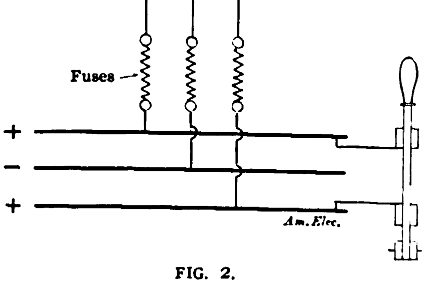

FIG. 2.

It is permissible, however, to make the cross-section of the neutral wire smaller than that of each outer wire, if one is reasonably sure that there will never be any changes such as those just mentioned, and if the drop in the two outer wires does not exceed 1½ per cent. Under such conditions, it will be found a very good rule to calculate the neutral wire of a principal feeder for a maximum unbalancing of 25 per cent—that is, a condition under which the current in one outer wire will be 75 per cent of the current in the other one, the current in the neutral being 25 per cent of that in the heavier-loaded outer wire. Thus, if the total load on a feeder were 199 amperes in each outer wire, on the supposition of a perfectly balanced load, and operating conditions compelled an unequal division to the extent of putting 228 amperes in one outer wire and 171 in the other, the neutral wire would carry 57 amperes, or 25 per cent of the 228 amperes carried by the heavier-loaded outer wire.

TABLE III.

For ascertaining the size of the neutral wire of a three-wire circuit.
Numbers in the body of the table are distances in feet.
Numbers in left-hand column are total loads in 3½-watt 16-c.p. lamps, counting the lamps on both sides of the neutral.
Table is computed for a drop of ½ volt in the neutral wire when the load is unbalanced 25 per cent.

Total Load.	Wire sizes; B. & S. Gauge:												
	0000	000	00	0	1	2	3	4	5	6	8	10	12
35	4000	3177	2518	1996	1578	1258	991	786	626	496	309	196	124
40	3500	2780	2203	1746	1382	1102	867	688	548	434	271	172	108
45	3111	2471	1958	1552	1228	978	771	611	487	386	241	153	96
50	2800	2224	1763	1397	1105	880	694	550	438	347	217	137	86
55	2545	2022	1602	1270	1005	800	631	500	398	315	197	125	78
60	2333	1853	1469	1164	921	734	578	459	365	289	181	115	72
65	2154	1710	1356	1075	850	678	534	424	337	267	167	106	66
70	2000	1588	1259	998	789	629	496	393	313	248	154	98	62
75	1866	1483	1175	930	736	587	462	367	292	231	144	91	57
80	1750	1390	1100	873	690	550	433	344	273	217	135	86	54
85	1647	1308	1036	822	650	518	408	323	257	204	127	80	51
90	1555	1235	978	776	614	489	385	605	243	192	120	76	48
95	1473	1170	927	735	580	463	365	289	230	182	114	72	45
100	1400	1112	880	698	552	440	347	275	219	173	108	68	43
110	1272	1010	800	635	502	400	315	250	199	157	98	62	39
120	1166	926	734	582	460	367	289	229	182	144	90	57	36
130	1077	855	678	537	425	339	266	211	168	133	83	52	33
140	1000	794	629	499	394	314	247	196	156	124	77	49	31
150	933	740	587	465	368	293	231	183	146	115	72	45	28
160	875	695	550	436	345	275	216	171	136	108	67	43	27
170	823	654	518	411	325	259	204	161	128	102	63	40	25
180	777	617	489	388	307	244	192	152	121	96	60	38	24
190	736	585	463	367	290	231	182	144	115	91	56	36	22
200	700	556	440	349	276	220	173	137	109	86	54	34	21
210	666	529	419	332	263	209	165	131	104	82	51	32	20
220	636	505	400	317	251	200	157	125	99	78	49	31	19
230	608	483	382	303	240	190	150	119	95	75	46	29	18
240	583	463	367	290	230	183	144	114	91	72	45	28	18
250	560	444	352	279	221	176	138	110	87	69	43	27	17
260	538	427	338	268	212	169	133	105	84	66	41	26	16

While unbalancing does not affect the total drop in the outer wires to the slightest extent, it does increase the drop at the lamps and, of course, the energy loss in the wiring; therefore, the resistance of the neutral wire should be made as low as practical considerations will allow, when it is not given a cross-section equal to that of both outer wires combined. Table III gives the lengths of neutral wires in which the drop will be ½ volt with a total load on the feeder of the number of 16-c.p. lamps stated in the left-hand column, and an unbalancing of 25 per cent. For example, a feeder carrying current for 100 lamps a distance of 68 feet would require a neutral wire of No. 10 gauge in order to keep the drop in that wire within ½ volt, with a maximum unbalancing of 25 per cent. This table will serve well enough for any circuit voltage between 100 and 125 on each side of the neutral, and for lamps of any standard commercial economy. Construction work does not permit of hair-splitting accuracy as to wire sizes and drop, even if the predetermined distribution of load were invariably obtained, which is not the case.

When the drop in the outer wires of a feeder exceeds 1½ per cent, the neutral wire will have to be as large as each outer wire, or larger, in order to keep the drop in it down to ½ volt with 25 per cent unbalancing. In sub-feeders and mains of three-wire construction, however, it will usually be sufficient to make the neutral wire equal in size to each of the outer wires, provided there is no likelihood of two-wire operation or a change to alternating-current distribution in the future. Consequently, Table III need be applied only to the principal feeders of such installations as are not liable to changes from the original plan of three-wire operation.

As an example of the practical application of the several tables, suppose that a three-wire feeder is to be run a distance of 150 feet, to a panel board from which are to radiate six sub-feeders, the lengths and loads of which are as follows:

Sub feeder	Load.	Distance.	Lamp-feet.
No. 1	60 lamps	55 feet	3300
No. 2	50 lamps	26 feet	1300
No. 3	21 lamps	25 feet	525
No. 4	22 lamps	40 feet	880
No. 5	10 lamps	30 feet	300
No. 6	16 lamps	20 feet	320
The feeder	179 lamps	150 feet	26,850

Assume further that the total drop in the feeder, sub-feeders and mains is limited to 2 per cent. The mains should be calculated for negligible drop, say ¼ of 1 per cent, so that turning on and off lamps will not affect the distribution appreciably; for similar reasons the drop in the sub-feeders should be considerably less than that in the principal feeder. The writer has found it a good plan to make the ratio of sub-feeder drop to main feeder drop from 1:2 to 1:3, but, of course, no hard-and-fast rule can be laid down. For convenience in the present example, assume that the sub-feeders be given ½ per cent and the main feeder 1¼ per cent drop. Reference to Table II will show that the nearest number to the lamp-feet of the feeder in the 1¼ per cent column is 26,765, which corresponds to No. 3 wire; and reference to Table I shows that this size will carry more than double the number of lamps required in the present instance, so that the outer wires of the feeder would be No. 3.

In Table III, for neutral wires, the nearest number of lamps to the number under consideration is 180, and the distance in this line nearest to the length of the feeder is 152 feet, which is found in the column at the head of which No. 4 wire is specified; this, therefore, would be the size of the neutral wire of the feeder.

Sub-feeder No. 1, having 3,300 lamp-feet, would need to be of No. 2 wire if it were made a two-wire line, so that it would be preferable to make it three-wire, using No. 8 wire, as specified by Table II for a drop of ½ per cent and 3,345 lamp-feet, this being the nearest to the actual number of lamp-feet. The neutral wire of this sub-feeder would be made the same size as each of the outer wires. Sub-feeder No. 2 could be made of No. 12 wire, if three-wire construction were used, but as the size for a two-wire feeder would be No. 6, most engineers would prefer to make it two-wire. (The usual preference appears to be in favor of two-wire sub-feeders and mains wherever they can be used without involving wire sizes so large as to be troublesome in the work of installing them, but the writer confesses to a strong preference for three-wire construction throughout, except when it compels the use of wires larger than the voltage drop requires.) All of the remaining sub-feeders would be two-wire, the wire sizes being taken from a 110-volt two-wire table. (These sizes work out as follows: Sub-feeder No. 3 of No. 10 wire; No. 4 of No. 8 wire; Nos. 5 and 6 both of No. 12 wire.)

In order to divide the sub-feeder loads as nearly equally as possible between the two sides of the feeder, Nos. 2 and 6 sub-feeders would be connected on one side of the feeder neutral and Nos. 3, 4 and 5 on the other side; No. 1 being a three-wire sub-feeder, the proper division of its load would be taken care of at the main or mains that it feeds.

Table III may be applied to cases involving other neutral wire drops and other percentages of unbalancing by multiplying the actual distance by a constant, K, and taking the result as the distance in using the table. Representing the desired neutral drop (in volts) by v and the desired percentage of unbalancing by u, the values of K will be $K = v \div 2$; or $K = 25 \div u$. If both the drop and the unbalancing are to be different, $K = 12 \times \frac{v}{u}$.

THE CARE OF INDUCTION MOTORS IN A LARGE FACTORY.

BY ARTHUR B. WEEKS.

The frequent use of individual induction motors in the different departments of the large factories of the present day necessitates a knowledge of their inspection and care. The following hints will, therefore, doubtless be of interest to those in charge of such plants.

Suppose it is nearly time for starting up a factory driven by induction motors. Each of these motors draws heavily on the system in starting; therefore it would be very unwise to wait until a few moments before starting time and start up each department simultaneously. One man should be responsible for the starting of all motors, taking one after another successively, in the order most convenient. Should the fuses of any motor blow in starting, leave that one until the others are started and then return to the disabled machine, rather than delay all the departments while one motor is receiving attention.

After all are started an inspection of each motor should be made as soon as possible. They might run indefinitely without causing any trouble; and, again, if neglected an hour, a hot box may result which will do a great deal of damage, besides throwing an entire department out of work for a time. The inspection should consist of examining each oiling ring to see whether it is revolving, feeling the bearings, to their condition as to heating, and looking for loose cables at the auto-starter or fuse boxes, or at the switches. Some men will insert a No. 0000 wire in a terminal post and depend upon one 12-24 brass screw to hold it in place. A faulty fuse box like this should be corrected; the wireman should solder the cable into a terminal for the block, so that the wire or cable may not work out and cause the motor to stop and the fuses to blow.

On starting an induction motor, should sparks be seen at the auto-starter, or at a fuse-block terminal, they will be due to poor contact and the connections should be tightened as soon as possible. Long stretches of cable without support at or near the fuse-blocks are liable to work loose. Fuses will also loosen because of vibrations. Go over all the system and tighten them occasionally.

Induction motor boxes do not need refilling often, but where the service is severe and the oil becomes dark, it is well to draw off some of the darkened oil and put in fresh oil up to the proper height. The writer has seen motors thoroughly saturated with oil by an inspector who poured in oil until it overflowed; this was always his gauge. Oil was spattered over walls and floors, and made a bad mess. It is only a question of time when the insulation will be rotted by such ignorance or gross carelessness.

There are plugs to be removed to drain the boxes, and sometimes it is next to impossible to get at them without special wrenches and many trials. This is due in some cases to not setting the motor in the right place, making it necessary for the motor pulley to be moved close up to the motor frame to bring it in line with the driven pulley. Sometimes tin guards placed over the belts also render the boxes inaccessible even for inspection; but even where such hindrances are encountered, the proper inspection must nevertheless be made.

In replacing the drip plugs, one may get the threads crossed; and, although the plug is finally forced in, yet oil is more than likely to drip out, and in a few hours drain the box. The remedy here is to get a proper size taper pipe tap, and retap the hole to some extent, but not too deep. It would also be a good plan to put some white or red lead on the plug, if it is likely to leak after tapping.

Saturday should be a day of general inspection; and if the plant shuts down in the afternoon, any motor that needs cleaning out inside can be attended to at this time. A motor as large as 50 horse-power can be managed by two men without the use of a block and tackle. Proceed with the work as follows: Draw the oil from the bearings. Bend one end of a piece of copper wire into a hook and with this lift the oiling rings up out of the grooves in which they revolve in order that they may not prevent the boxes moving on the shaft or become bent if one uses force before realizing what is holding the boxes.

Run the motor back to remove the belt. In most cases it will also be necessary to remove the pulley. Loosen the set screws and draw out the key. If fitted tight, more than ordinary ingenuity may be required to get it started and a special tool may even have to be made for the purpose. The pulley, too, may have rusted on, or been driven on, and another motor may also have been placed so near it, or it may be so close to a wall, that difficulties multiply. Sometimes one can get a pry between a pulley and motor frame with a crow-bar. A very large pulley can be pulled off when every other method has failed by placing a screw jack against the end of the shaft and passing a chain around it and two spokes of the pulley. Make secure and tighten on the screw jack. The writer has removed fly-wheels, key and all, in this way.

Remove the nuts from both sides of the motor frame. Pry the pulley side off first as far as it will go; then run a screw-driver or drift through the bolt holes on each side, and two men can easily lift that part off. Do the same with the other side. Next, if air for blowing out is available, turn it on and clean the machine thoroughly. All motors should be periodically given the same treatment.

Next push the rotor (armature) each way as far as it can go, removing it entirely if possible. Give all the exposed wires a thorough cleaning with clean waste, and paint thoroughly with some first-class insulating varnish, such as Sterling or Ajax. All the exposed wires at both ends of the machine should be varnished. This is the most essential painting, as it is at these places that the oil accumulates.

Since dirt collects in and around the boxes it is necessary to wash them out. Gasoline or benzine is excellent for this purpose. Hold the end frame upright (in the normal position when on the motor) and place a can at the oil drain pipe or plug to catch the liquid. Pour the gasoline through the box and clean it thoroughly. The parts can now be replaced and reconnected. Afterward pour the proper amount of oil into the boxes, and *be sure not to forget to put the oil rings back in place.*

If during any part of the work any unusual force is required to get any part together examine it carefully to locate the cause. Tighten up bolts equally on opposite sides at the same time so as to prevent binding. Two men, one at each end at the same time, can manage this better than one alone. Do not forget to tighten the set screws in the pulley and run the motor back in place afterward. Keep watch of the bearings for some time after starting, so that in case anything is not right it can be caught in time to prevent further trouble.

With the inspection of motors should be included the cleaning of them. Even in locations where dust accumulates, if the cleaning is done once a day, regularly, but a short time will be required to keep things clean. If cleaned only once in several days the motors will be dirty the greater part of the time, and the labor of cleaning materially increased.

Examine fuse blocks where fuses blow oftener than is necessary, and instead of merely replacing the fuse, see if one of the wire terminals is not loose, since that is frequently the cause of fuses letting go. The practice of some men has been to use a larger fuse, to prevent frequent fusing. This is certainly a poor policy, especially if the block is already fused to the safe carrying capacity of the wire that it is to protect.

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Suspended Railway for Berlin.—It is proposed to construct for Berlin suburbs a "hanging" electric railway, to extend from the station Gesundbrunnen, run through the Brunnenstrasse to the Rosenthaler Thor, and from there to the Alexander Platz station, Oranienburger Platz, Kottbuser Thor, Hermanns Platz, passing through the suburb Ricksdorf, and ending at the station of the belt line at the Hermanns Platz. The managers of the proposed "hanging" road claim that their system has many advantages over the ordinary elevated lines; less building material will be needed in the erection of the superstructure, as the cars would be suspended from the structure and would require only one track; sharper curves would be possible, and even at the sharpest curves trains can run at a high rate of speed. The high tracks would not darken the streets as do ordinary superstructures of the elevated roads. The line as proposed would have a length of about six miles, and it is proposed to operate three motor cars, each having fifty seats. Later it is hoped to run trains of six cars. The road would be able to carry 9,000 passengers in an hour. The cost of operating it would, it is claimed, be much less than for other lines.

Lessons in Practical Electricity

THE ELECTRIC ARC.

If two pieces of carbon, or similar material, be connected electrically to the terminals of a dynamo or other source of current, and the free ends of the carbon pieces touched together, current will of course flow through the closed circuit thus established. Now if the pieces of carbon be drawn out of contact with each other, and separated to a limited extent, such as ⅛ inch, an *arc* will be formed between the two carbon ends, owing to the vaporization of the carbon by the intense heat of the spark which is caused when the circuit is first broken. Opening a circuit always causes such a spark, but an "arc" will not be established unless there is sufficient electrical energy available at the break to vaporize the conducting material there.

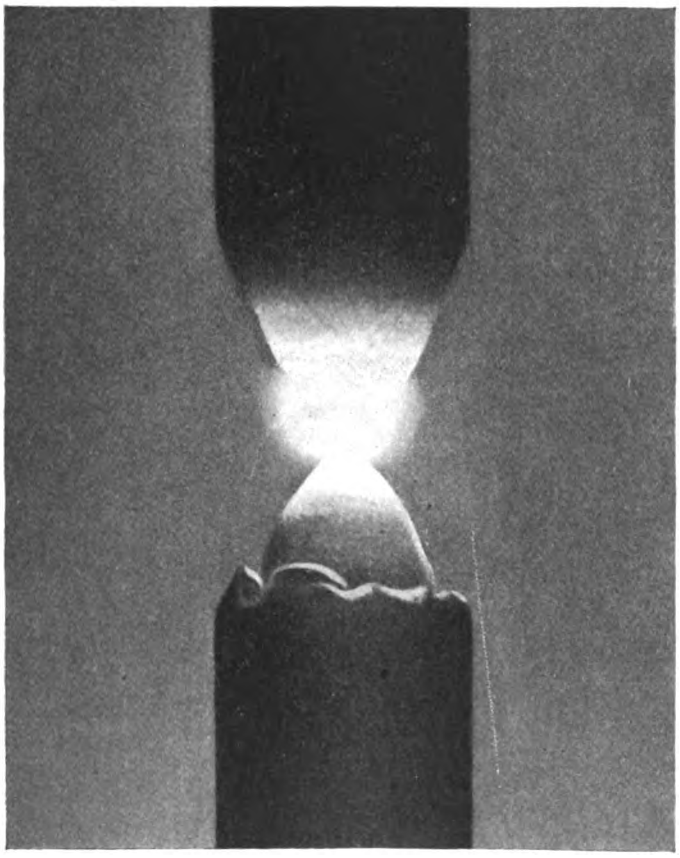

FIG. I.—THE ELECTRIC ARC.

An arc formed between two pieces of carbon gives out an intense light, the color effect of which depends upon the length of the arc, quality of the electrodes and strength of the current. In general, taking a white arc as the starting point, increasing the length of the arc or decreasing the current will cause the arc to take on a violet tinge; contrariwise, a white arc takes on first a yellowish tinge and then a reddish one, if the length of the arc be decreased. The inner part of the arc "stream" or flame, or whatever one may choose to term it, is of a violet color, and this is surrounded by a sheath of yellowish flame, in which the carbon vapor is apparently burned to carbonic acid gas. The carbon tips are white-hot at the center and red-hot at the edges. These facts lead to the conclusion that the changes in color may be explained as follows:

Decreasing the current in an arc of normal length decreases the white-hot area on the ends of the carbons and also decreases the combustion of carbon vapor, allowing the violet rays from the "core" of the arc to predominate. Increasing the length of the arc has the same effect because the violet "core" is longer and the average temperature of the carbon tips is reduced. Shortening the arc reduces both the violet rays and the area of white-hot carbon that is visible (the edges of the carbon tip partly shielding the center), allowing the yellow rays from the burning carbon vapor to predominate; further shortening reduces these rays and still further shields the white-hot centers of the carbons, leaving the red-hot edges of them to supply practically all of the light. With an arc of normal length, increasing the strength of the current will increase the whiteness of the arc and the quantity of light emitted.

In applying the electric arc to practical illumination, round carbon pencils are used, butted end to end and mounted vertically. The carbon to which the positive supply wire is connected is known as the positive carbon, and the other one is of course the negative carbon. The upper carbon of the pair is made the positive one, for the reason that the principal consumption of energy occurs at the center of the end of this carbon and boils carbon particles off in such a manner as to hollow out the end and form a crater, the center of which is the most luminous part of the arc. If this carbon were the under one, the edges of the crater would shield the chief source of illumination.

The two carbon tips burn to the shapes shown by Fig. 1. A large proportion of the carbon particles detached from the positive electrode are carried over and deposited on the negative tip, building it up as shown, and partially compensating for the wasting away there due to combustion. Because of this action the positive carbon is consumed nearly twice as rapidly as the negative one. The wasting away of the carbon rods necessitates the continual adjustment of the relative positions of the two so as to keep the distance between the tips practically constant; otherwise the arc would grow longer and longer until it finally "broke" and discontinued on account of the high resistance of its path.

This resistance, like that of any other electrical path, is proportional to the length of the arc and inversely proportional to its mean effective cross-sectional area and to the quality of material in the path. These values are very difficult, if not impossible, of determination, and are not of very great practical importance. With 9.6 amperes passing, the resistance of an arc per inch of length (distance from the crater center to the negative crest) is roughly 4 to 5 ohms, but it is affected by the current density per square inch of crater area, as this affects the rate of vaporization of carbon and consequently the conductivity of the path.

The amount of light given out by the arc of a commercial lamp, as intimated above, depends almost entirely on the current strength and the length of the arc. The effective illumination depends wholly upon the angle at which the light rays are received from the arc. The maximum is usually found at an angle of 40° to 50° below an imaginary horizontal line drawn through the center of the arc, and is about 1,200 candle-power in the case of an ordinary 9.6-ampere arc surrounded by a clear globe. As will be explained in a later Lesson, this is not a criterion of the practical illuminating value of an arc.

Letters on Practical Subjects

Operating Induction Coils From Lighting Circuits.—A Convenient Test Board.

To the Editor, American Electrician:

In the Queries and Answers Department of a recent number of the AMERICAN ELECTRICIAN, I noticed an inquiry signed "C. M. G.", concerning the operation of induction coils from ordinary lighting circuits, and I take the liberty of submitting herewith a diagram of connections showing a method which I have used for thus operating induction coils. The primary circuit of the coil is connected in series with a

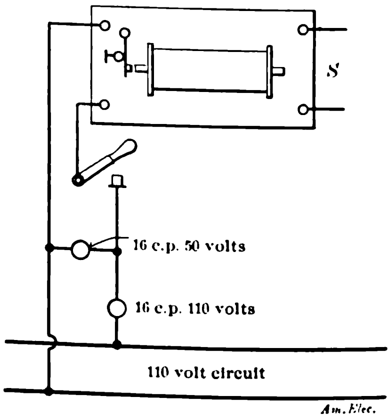

FIG. I.—INDUCTION COIL CONNECTIONS.

16-c.p., 110-volt lamp, and is shunted by a 16-c.p., 50-volt lamp which serves to reduce the spark at the vibrator contact. This arrangement has given entire satisfaction with small coils; for coils requiring large primary current, the 50-volt lamp would, of course, be displaced by a non-inductive resistance of suitable value.

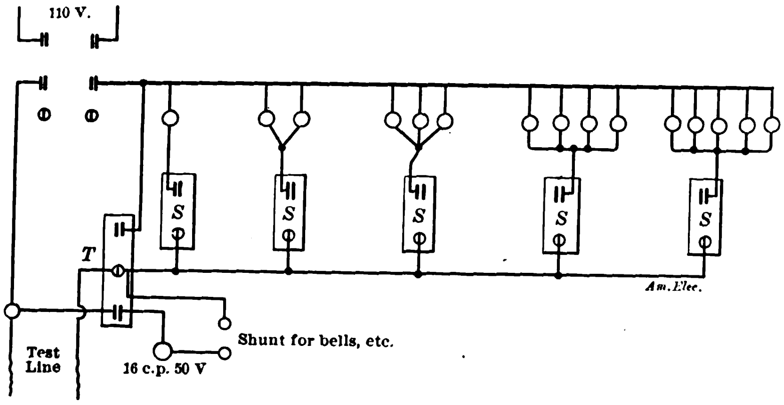

FIG. 2.—CONVENIENT TEST BOARD.

The second diagram sent herewith illustrates a handy testing board for shop purposes, which can be constructed with little expense and will be found of great convenience. It consists of incandescent lamps connected in groups, as shown, each group being controlled by a single-pole switch, *S*. The diagram shows the circuit of the lamp bank short-circuited by means of the double-throw single-pole switch, *T*. This enables the test line, which is now connected directly to the two sides of the supply mains, to be used at the full voltage. A shunt circuit is taken off for the purpose of testing bells and similar low-voltage apparatus, this circuit being connected to the main circuit through a 50-volt lamp. When it is desired to use the bank of lamps for testing, the double-throw switch, *T*, is opened. Throwing this switch downward makes the lamps available for illuminating purposes.

San Francisco. ARTHUR BARTHELS.

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Unusual Dynamo Performance.

To the Editor, American Electrician:

I have temporary charge of two 500-kw., 500-volt compound-wound dynamos, which are direct-driven by their respective engines. The rotation of the armature of one machine is clockwise, while the other armature is driven in the opposite direction, as indicated in the accompanying sketches. The heavy circles represent the rings connecting groups of brushes of like polarity. These machines have been in use for nearly two years, and there has been very much commutator trouble with the machine which is driven clockwise; the commutator has had to be turned off several times. The speed of the engine driving this machine fluctuates continually, while the engine driving the other dynamo runs steadily. The two generators are positively connected up exactly alike, as shown by the sketches, and the exciting current traverses the field windings in the same direction as indicated by the arrows. The commutator of the machine running clockwise blackens and burns in spots, these spots corresponding in number to the number of field-magnet poles, which commonly occurs with machines that have been reversed and are kept running in that condition. It seems entirely wrong, of course, to have the two generators connected up alike when the armatures are running in opposite directions (facing the commutators), but this is indisputably the case. It is still more queer that the machine which is apparently connected up properly is the one which gives the trouble at the commutator. I should like very much to have some of your readers express opinions as to why it is possible to operate the two machines oppositely, and also as to the cause of the commutator trouble on the machine running clockwise. Is it the irregular speed of the engine that causes a continuous pumping of current back and forth between the machines through the equalizer connection? The conditions are such that the machines have to be kept running twenty hours out of the twenty-four, so that there is no time to go over them and make any analysis or corrections of the trouble.

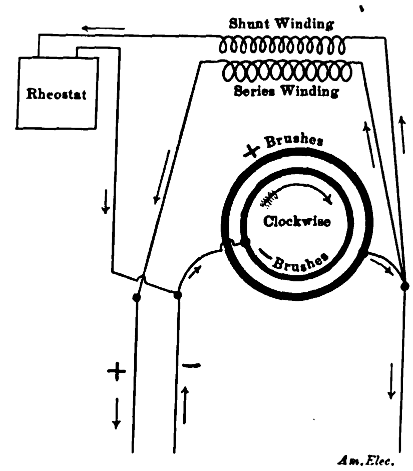

FIG. 1.—UNUSUAL DYNAMO PERFORMANCE.

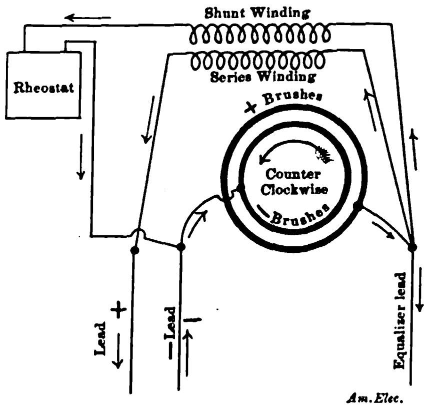

FIG. 2.—UNUSUAL DYNAMO PERFORMANCE.

New York. H. B. CHARLES.

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Mr. Lohman's Problem in Lighting Circuits.

To the Editor, American Electrician:

Please find enclosed a diagram (Fig. 1) giving a solution of Mr. Lohman's problem in boiler-room lighting circuits. The diagram is intended to show four single-pole knife-switches for controlling the lamp circuits, switches Nos. 1 and 2 being single-throw, and Nos. 3 and 4 double-throw. As two lamps must always be in series no matter what the combinations, one terminal of each lamp is connected to one terminal of every other lamp. With switches Nos. 1 and 2 closed, lamps *b* and *c* will be lighted. With Nos. 3 and 4 closed either to the right or to the left (both being closed in the same direction), lamps *a* and *d* will be lighted. With No. 1 closed and No. 3 closed to the right, lamps, *a* and *b* will be lighted. With No. 1 closed and No. 4 closed to the left, lamps *b* and *d* will be lighted: With No. 2 closed, throwing No. 3 to the left will light lamps *a* and *c*, or throwing No. 4 to the right will light lamps *c* and *d*. With Nos. 1 and 2 closed and Nos. 3 and 4 both thrown either to the right or to the left, all of the lamps will be lighted.

Winchendon, Mass. GEO. A. BURNHAM.

To the Editor, American Electrician:

Referring to Mr. Lohman's problem which appeared in the December number of the AMERICAN ELECTRICIAN, the accompanying diagram (Fig. 2) is submitted, as showing one method of fulfilling the requirements. Six single-pole knife-switches are used for controlling the lamps. The lamps are permanently connected on one side, so that any one lamp may be put in series with any one of the other three lamps. With switches Nos. 1 and 6 closed, lamps *a* and *b* will be lighted. Switches Nos. 2 and 6

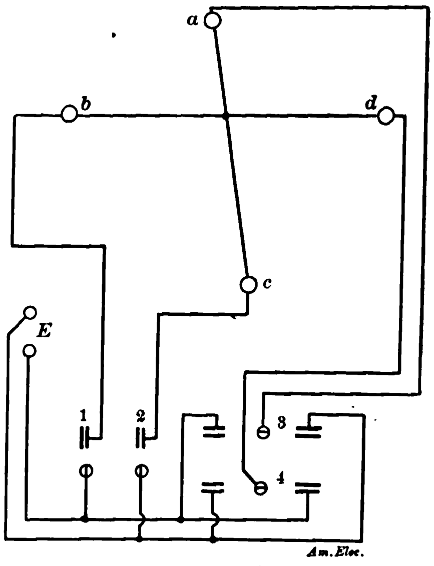


FIG. 1.—MR. BURNHAM'S SOLUTION.

will light lamps *a* and *c*, and switches Nos. 3 and 6 will light *a* and *d*. It will be obvious that any other combination of two lamps in series may be effected by means of the switches, and that all four may be lighted simultaneously by closing switches Nos. 1, 2, 5 and 6. FRED KREBS.

Missoula, Mont.

To the Editor, American Electrician:

The accompanying diagram (Fig. 3) fulfills, I think, all of the requirements of Mr. T. H. Lohman's problem in boiler-room lighting circuits, which appeared in the December number of your paper. The lamps are all interconnected permanently on one side, the other terminal of each lamp being carried to the bank of switches. Two single-throw and two double-throw switches are used; these may be, of course, all of the baby knife pattern, or of the ordinary snap switch type. With No. 1 closed, throwing switch No. 2 to the right will light lamps *a* and *b*, while leaving switch No. 2 open and throwing No. 3 to the right will light lamps *a* and *c*; closing switches Nos. 1 and 4 will light lamps *a* and *d*. Lamp *d* may be combined with either lamp *b* or *c* by throwing over to the left the double-throw switch connected to whichever lamp is desired. Closing switches Nos. 1 and 4 will light lamps *a* and *d*, and with these switches closed, the closure of switches Nos. 2 and 3 in opposite directions will cause all four lamps to be lighted. GEORGE W. MALCOLM.

Brooklyn, N. Y.

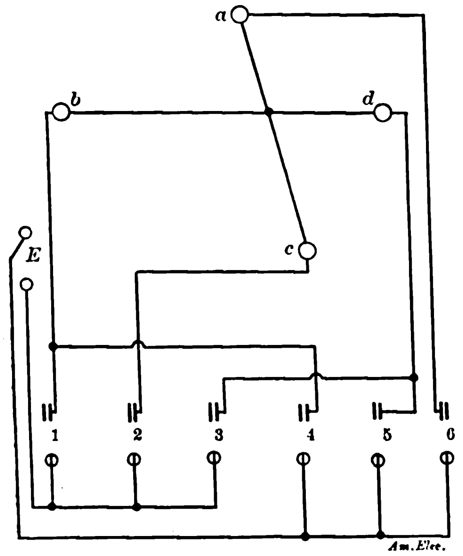


FIG. 2.—MR. KREBS'S SOLUTION.

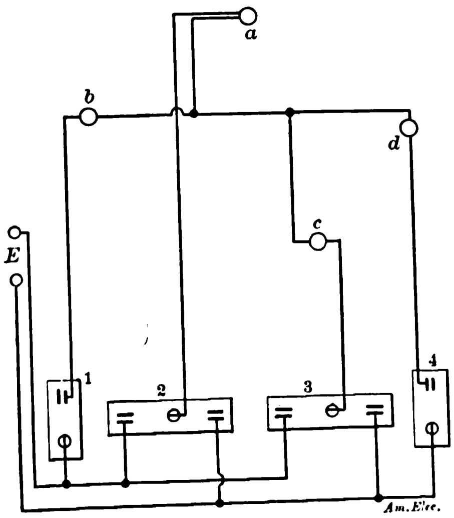


FIG. 3.—MR. MALCOLM'S SOLUTION.

To the Editor, American Electrician:

The diagram submitted herewith (Fig. 4) is intended as a solution of Mr. Lohman's problem in connections, which was published in the December number of the AMERICAN ELECTRICIAN. The lamps are cross-connected permanently, as shown by the diagram, only one terminal of each lamp being carried to the switches. These are three double-pole, double-throw switches of the knife and jaw type. With switch No. 1 closed upward, lamps *b* and *c* will light, while throwing this switch downward will light lamps *a* and *b*. Throwing No. 2 upward will light lamps *a* and *c*, and throwing it downward will light lamps *b* and *d*. No. 3 thrown upward will light lamps *c* and *d*, and thrown downward will light lamps *a* and *d*. Closing switches Nos. 1 and 3 in opposite directions will light all four lamps, No. 2 being of course left open.

San Mateo, Cal. CHARLES MORRISON.

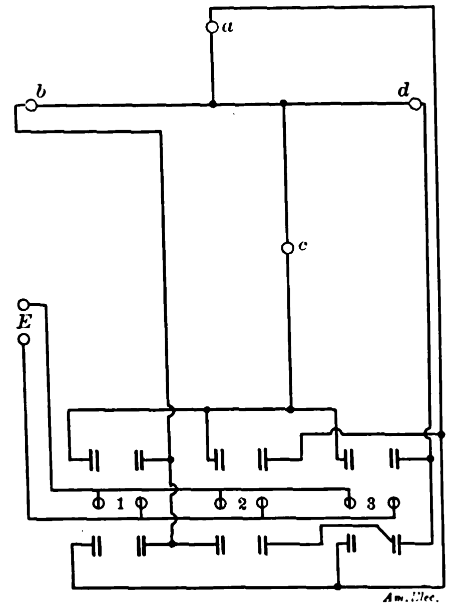


FIG. 4.—MR. MORRISON'S SOLUTION.

To the Editor, American Electrician:

I enclose a solution (Fig. 5) of Mr. Lohman's problem which appeared in your December issue. The switches shown in the diagram are intended to be double-pole, double-throw knife-switches and are numbered for identification. Throwing switch No. 1 to the left lights lamps *b* and *c*; throwing it to the right will light lamps *c* and *d*. Switch No. 2 thrown to the left lights lamps *a* and *c*, and thrown to the right lights lamps *a* and *b*. Throwing No. 3 to the left will light lamps *a* and *d*, and throwing it to the right will light lamps *b* and *d*. With Nos. 1 and 2 closed to the right, all four lamps will light. This may also be accomplished by closing Nos. 1 and 3 to the left, or No. 2 to the left and No. 3 to the right. It will doubtless be observed that with No. 1 thrown to the right and No. 2 thrown to the left, or with No. 2 thrown to the right and No. 3 thrown to the left, the mains will be short-circuited. This may be easily avoided by mounting the switches so that when the handles of two adjacent switches are thrown toward each other the handles will interfere with each other, making it possible only to close one of the switches. It may also be noted that with two of the switches closed in other positions than those mentioned above, two of the lamps will be put in parallel with each other and in series with one of the other lamps, which would hardly be fair to the single lamp. It is assumed, however, that whoever handles the switches has better sense than to do this. C. H. POOL.

New York.

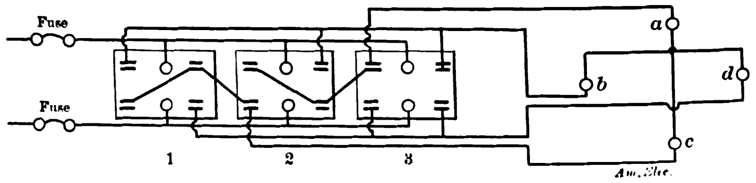


FIG. 5.—MR. POOL'S SOLUTION.

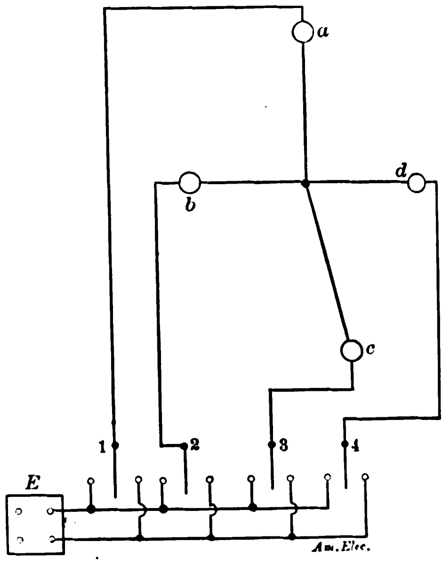


FIG. 6.—MR. TIBBALS' SOLUTION.

To the Editor, American Electrician:

The accompanying diagram (Fig. 6) is a simple solution of the problem submitted by Mr. T. H. Lohman in the December number. In order to reduce the amount of wire necessary, the lamps are cross-connected and wires are carried to the switches from one terminal of each lamp only. Double-throw, single-pole switches are used, the connections of which are obvious from the diagram. It will be plain that any two lamps, or all four, will be lighted by closing the proper switches in the proper direction. This arrangement has the disadvantage that one lamp may be connected to series with either two or three lamps in parallel, which might result disastrously for the single lamp. As this will be apparent at once to whoever manipulates the switches, it is not probable that they would be left closed in the wrong position. J. M. TIBBALS.

Kansas City, Mo.

[Fig. 7 illustrates the method of connection actually used by Mr. Lohman in the solution of his problem. He uses only two single-pole, double-throw switches. Throwing No. 1 to the right and No. 2 to the left will light lamps *c* and *d*. Throwing both switches to the right will light lamps *a* and *d*; throwing both switches to the left will light lamps *b* and *c*, and throwing No. 1 to the left and No. 2 to the right will light all of the lamps. It will doubtless be observed that Mr. Lohman's solution does not completely fulfill his own requirements, as stated in the problem, in that it is impossible to light lamps *a* and *b* without lighting all four lamps; it is also impossible to light lamps *a* and *c* together, or lamps *b* and *d* together.

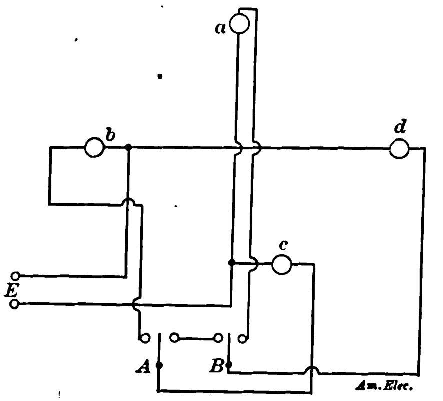


FIG. 7.—MR. LOHMAN'S SOLUTION.

The solutions of Mr. Burnham and Mr. Malcolm are practically identical and appear to be the only complete solutions which do not involve a short-circuit objection. All of the plans render it possible to burn out one of the lamps by connecting it in series with two of the other lamps connected in parallel, and the solutions of Messrs. Krebs and Morrison make it possible to short-circuit the line. Mr. Morrison's solution could be freed from this objection by arranging the switches, as suggested by Mr. Pool, so that the handles of Nos. 1 and 2 would interfere with each other in the case of an attempt to close the switches so as to short-circuit the line.—EDITOR.]

An Electrochemical Question.

To the Editor, American Electrician:

I submit herewith a question in electrochemistry on which I would like expressions of opinion through your columns. In the accompanying diagram the current required by the 110-volt lamps, *l*, passes first through a resistance, *r*, which shunts about 1/100 part of the current through the platinum electrodes, *t* and *t*, which are surrounded by an electrolyte of commercially pure sulphuric acid and water in a glass receptacle. The gases generated collect in the glass reservoir, *C*, and can be recombined therein by the sparking arrangement at the top. When this is done the register, *R*, indicates that the entire volume of gas atoms are reunited into liquid molecules of the original bulk.

The question arises: Is the voltage across *t, t,* sufficient to decompose only the H_2O molecules, or is the sulphion radicle SO_4 also broken up, and if so, in what manner do its atoms again reunite or combine? Authorities advance the latter theory, while I claim the former, but I would like clear proof for either. W. A. SHERLOCK.

San Francisco, Calif.

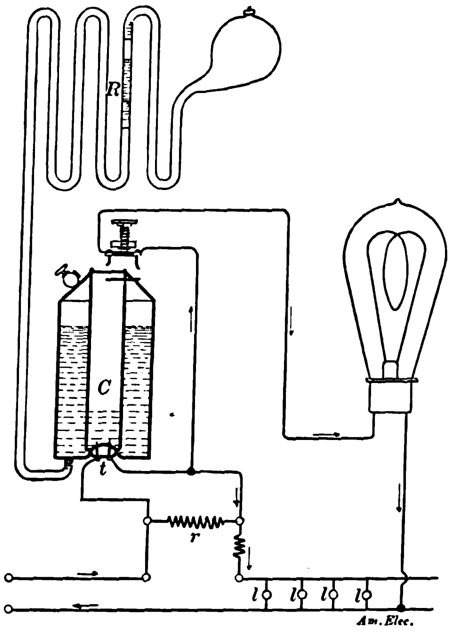


FIG. 1.—ELECTROCHEMICAL QUESTION.

Electrical Catechism

721. How is tin deposited electrolytically?

Although the deposition of tin by simple dipping, or by contact with zinc is exceedingly useful for small articles, the deposition of this metal by direct current is far more reliable when deposits of considerable thickness are required. There is, however, one drawback connected with the electrodeposition of this metal, which stands much in the way of its practical usefulness, and renders its deposition more costly than would otherwise be the case, namely, that the anodes do not dissolve in the bath in the same ratio as the deposit on the cathode; consequently the strength of the bath requires to be kept up by constant additions of some salt of the metal to the solution while deposition is taking place. A good bath is composed of 600 grammes of protochloride of tin in crystals, 5 kilogrammes of pyrophosphate of sodium or potassium and 500 litres of distilled or rain water.

722. What precautions are necessary in depositing tin with this solution?

In making up the bath, the water is put into a tank lined with anodes of sheet tin, united together and put in connection with the battery. The pyrophosphate salt is then put into the tank, and the liquid stirred until this is dissolved. The protochloride of tin is placed in a copper sieve, and this half immersed in the solution. A milky-white precipitate is at once formed, which becomes dissolved by agitation. When the liquid has become slightly yellow, the bath is ready for use. The solution of these salts should always be made with the aid of a sieve, for if the fragments of the protochloride tin were to fall on the bottom of the bath they would become coated with a slowly soluble crust, preventing their dissolving. It is stated that any metal may be coated in this solution with equal facility, and that a good protective coating may be obtained with it, while the metal has a dead white lustre resembling that of silver, which may be rendered bright either by scratch-brushing or by burnishing. A strong current is necessary in working this solution.

723. How may platinum be deposited electrolytically?

The peculiar attributes of this interesting metal, its resistance of the action of corrosive acids or other substances render it invaluable in the construction of chemical apparatus, while its high cost, its infusibility and the great difficulty experienced in giving this metal any required form greatly limit the area of its usefulness. One great difficulty that stands in the way of depositing platinum economically and of any required thickness is that the anodes do not dissolve in the solutions which have as yet been adopted for its deposition. Consequently, unless repeated additions of the platinum salt are made, as the solution becomes exhausted, it is impossible to obtain a coat of sufficient thickness for any practical purposes. A cyanide bath, from which platinum may be deposited by the use of a rather weak current from a Daniell cell, is made with a quantity of chloride of platinum solution, representing about 5 pennyweights of metal with sufficient distilled water added to make up one pint. To this is added a strong solution of cyanide sufficient to precipitate and redissolve the platinum. A little cyanide is added in excess and the solution filtered; distilled water sufficient to make up the solution to one quart is then added. This solution should be heated to about 130° Fahr. when in use. Roseleur recommends a solution from which platinum may be deposited, which consists of 10 parts of chloride of platinum and 500 parts of distilled water. The chloride is dissolved in the water, and if any cloudiness appears, it must be filtered. One hundred parts of crystallized phosphate of ammonia is then mixed with 500 parts of distilled water and added to the platinum solution with brisk stirring, when a copious precipitate will be formed. To this is added 500 parts of phosphate of soda dissolved in twice as much water. This mixture is to be boiled until the smell of ammonia ceases to be apparent and the solution, at first alkaline, becomes acid. The yellow solution now becomes colorless and is ready for use. It is to be used hot with a strong current and is recommended for depositing platinum upon copper, brass and German silver. It is unsuited for coating zinc, lead or tin, since these metals decompose the solution and become coated in it by simple immersion. Since the platinum anode is not dissolved in the solution, fresh additions of the chloride are necessary.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Which would be preferable, two engines of 5 and 7 horse-power respectively coupled to one shaft, or a single engine of 12 horse-power?
G. M.

The single 12-h.p. engine.

Can a 110-volt dynamo be operated as a motor on a 550-volt circuit without changing the windings?
C. E. G.

Certainly not; the voltage of any direct-current machine is practically the same whether operated as a motor or a dynamo.

If current is applied to the brushes of a direct-current armature driven by a belt, could any current be taken from the terminals of the field winding of the machine, and if so, would it be alternating or direct?
C. A. M.

No.

Is it allowable in conduit work to use a bent piece of pipe instead of an elbow? (2) Is a 14-c.p. 14-volt battery lamp more efficient than an ordinary 110-volt incandescent lamp?
G. I. B.

Yes; it is preferable. (2) As a rule, yes.

What is the solution used in an electric forge?
C. M. L.

Washing soda and borax dissolved in water. A good proportion is 10 pounds of washing soda and 2 pounds of borax to 40 gallons of water.

How can a fan motor built for 16,000 alternations be adapted to run on a circuit of 7200 alternations?
A. V.

By changing the connections of the field-magnet coils so that each pair of adjacent poles would have the same polarity if the winding were supplied with direct current.

What is the formula for finding the middle ordinate of the chord of a circular arc?
W. H. P.

Representing the radius by *R* and the length of the chord by *C*, the length of the ordinate will be given by the formula,

$$R - \sqrt{R^2 - \frac{C^2}{4}}.$$

How may the constant of a Siemens dynamometer be obtained?
F. D. B.

Pass a moderate current through the dynamometer in series with a standard ammeter, adjust the current to a convenient value and note the number of degrees through which the torsion head of the dynamometer must be turned in order to bring the pointer to zero. Dividing the current by the square root of the number of degrees will give the constant of the dynamometer. Expressed in the shape of a formula,

$$\frac{I}{\sqrt{D}} = K.$$

Can an ordinary induction motor be operated as a generator? (2) If one of two direct-current generators running in parallel be driven by its mate as a motor, will the direction of rotation be the same as before or opposite?
M. J.

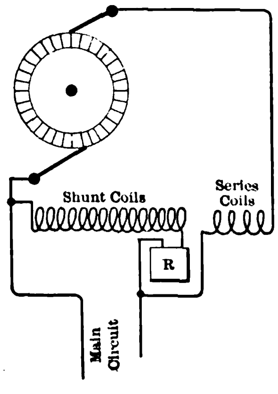
Yes, but it must be operated in parallel with some such machine as an ordinary alternator or a synchronous motor in order to maintain its excitation. (2) It will continue running in the same direction, but at a considerably higher rate of speed.

A compound-wound 75-h.p. motor is driving a brick machine, and it frequently happens that dry mud and stones get into the machine and throw on an abnormal load very suddenly, causing an objectionable rush of current through the motor. As the series winding tends to reduce the speed of the machine, could not the rush of current be reduced by shunting the series winding?
J. M.

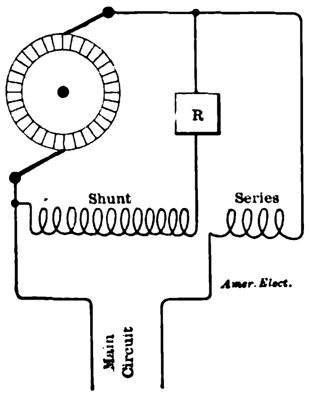
No. With the series winding shunted, or cut out, the motor would require more armature current than it does now to overcome the abnormal drag imposed by the overload. Your only remedy is to keep dry mud and stones out of the machine.

Which is preferable in the case of a compound-wound direct-current dynamo, the long-shunt or short-shunt connection?
F. M. D.

The long shunt is usually preferable when two or more machines are operated in multiple, since the shunt winding may be excited directly from the switchboard busbars. When only a single machine is operated on a given circuit, however, there is no preference between the two methods of connection.



LONG SHUNT.



SHORT SHUNT.

What is the difference between the voltage ratio of the primary and secondary windings of a transformer without any iron core and one with the usual core? (2) If the ratio of transformation is the same for a given ratio of secondary to primary turns in both cases, why is a core necessary?
J. C. T.

The ratio of e.m.fs is practically the same with or without the core. The function of the core is to reduce the reluctance of the path followed by the magnetic lines of force set up by the primary winding. Without any core, the magnetizing or no-load current of the transformer would be enormously greater than with the core, and the efficiency would be uncommercially low.

What precautions are necessary for starting up a motor, either series or shunt-wound? (2) What is the best method of operating 16-c.p. incandescent lamps from an arc light circuit?
C. J. Y.

No precaution is necessary with a series-wound motor, if it is provided with a governor, other than to examine the governor and see that it is in free working order. If the machine has no governor, it should not be started up without a considerable load. With a modern starting-box, no precautions are necessary in starting up a shunt-wound motor, except to refrain from cutting out the resistance so rapidly as not to give the armature time to accelerate its speed properly. (2) There is no thoroughly satisfactory method of operating incandescent lamps from an ordinary series arc lamp circuit.

If the load is increased on an automatic high-speed engine having a governor which varies the lead of the valve as well as the point of cut-off, does the lead increase or decrease? (2) When several engines exhaust into one condenser, is more coal consumed if one of the idle engines is run slowly by the vacuum, the throttle valve being closed?
W. W. J.

The governor increases the lead of the valve with an increase of load. (2) Most assuredly; you cannot operate an engine by any means whatever without using power. In a case such as the one assumed, however, the engine would not be run "by the vacuum," but by leakage of steam through the throttle valve.

What is the power factor of a direct-current motor? (2) What effect does the power factor of a motor have on its efficiency? (3) Are the copper conductors of the armature of an induction motor insulated from the core?
W. E. T.

The term "power factor" is not used in connection with direct-current motors, as these motors always have a power factor of 100 per cent. (2) Only a very small effect due to the increased loss in the windings as the power factor is decreased; but it reduces the efficiency of the transmission wires and also reduces the maximum allowable output of the generating plant in true watts. (3) In some cases the conductors of the squirrel-cage type of rotor are insulated and in others they are not. The conductors of a wound rotor must be insulated.

What is a simple way of telling whether a current of known voltage, but unknown characteristics, is alternating or direct? (2) Will a medical coil, or an induction coil such as is used with telephones, work as well with alternating current as with a pulsating direct current?
C. V.

Wind a coil of small wire around a laminated core and test the resistance of the coil with current taken from a battery. Then connect the coil in series with a 32-c.p. lamp made for the voltage of your circuit, and measure the current flowing through the test coil and the drop at its terminals. If the resistance of the coil thus determined is the same as that ascertained by means of the battery current, then your circuit current is direct. If the resistance (more properly, impedance) is higher than that shown with the battery current, then the unknown current is alternating. (2) A medical coil will not operate as satisfactorily with alternating current as with pulsating current. A telephone induction coil operates with alternating current when used in telephone work; used as an ordinary induction coil, it will not work as well on alternating current as on pulsating direct current.

WOODWARD FRICTION WATER-WHEEL GOVERNOR.

One of the most important considerations in the operation of steam as well as of water-driven plants, is the governing of the prime mover. Were the conditions of load and power available always the same, no governor would be necessary, but unfortunately such an ideal condition does not exist; and in the operation of electric plants, where so much depends upon the uniformity of speed, notwithstanding the conditions of load, the governing of prime movers becomes of vital importance.

One of the latest additions in the domain of hydraulic engineering is the Woodward friction water-wheel governor, manufactured by the Woodward Governor Company, of Rockford, Ill., and shown by Fig. 1 herewith. This is of the compensating, horizontal type. Power to operate the governor is supplied from the main shaft of the water-wheel installation and is delivered to the shaft of the governor by the large pulley shown in the rear. On this shaft is mounted a compressed paper friction, and supported by sleeves on this main shaft are two pans, which, when pressed against the friction, move the gates of the turbines in either direction by means of suitable gear connection to an intermediate shaft shown in the foreground and more clearly in Fig. 2, this intermediate shaft being connected in turn to the turbine gate shaft.

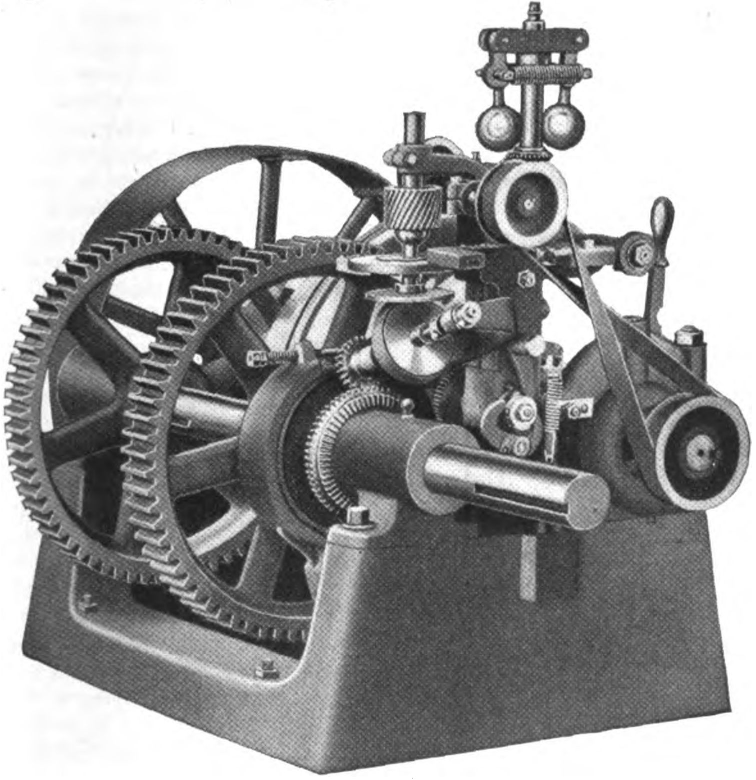


FIG. 1.—WOODWARD FRICTION WATER-WHEEL GOVERNOR.

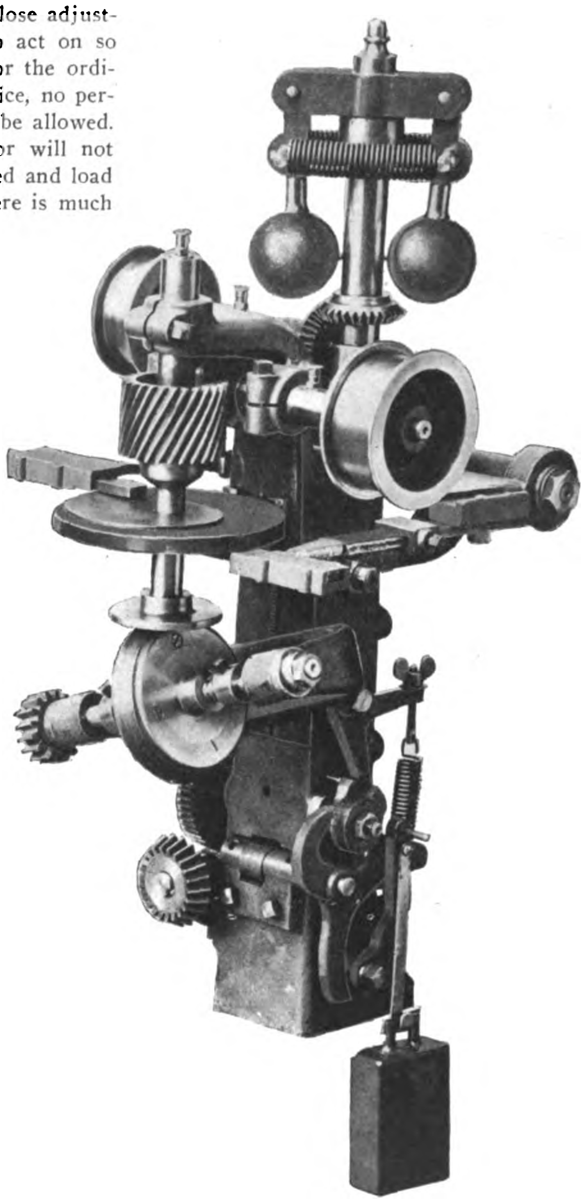


FIG. 2.—DETAILS OF CONTROLLING MECHANISM.

The speeder balls of the governor are separately driven from the main shaft of the installation. There is also a cam continuously revolved by means of a belt and a spiral gear, which can be plainly seen in Fig. 2. This cam will be noticed just below the spiral gear. As the speed changes the rod of the speeder raises and lowers, carrying with it the tappet arms and tappets. These tappets can be seen one above and one below the cam just mentioned. As soon as a change of speed occurs, either one or the other of the tappets, as the condition demands, is engaged by the cam and forced out from its center.

This motion is then conveyed through suitable crank shafts to the main shaft on which is mounted the friction, and as this shaft is forced back and forth the friction is brought to bear on either the opening or closing pan. When the speed is normal this cam revolves between the upper and lower tappets without engaging either. The cam mechanism is capable of very close adjustment, enabling the governor to act on so small a change of speed that for the ordinary conditions of lighting service, no perceptible variation of speed will be allowed. At the same time, the governor will not act upon the gate when the speed and load are steady, and consequently there is much less wear on the gate mechanism than with a governor that keeps the gate in continuout motion although so slight as not to affect the speed.

Just below the cam and fastened to the same shaft is a concave disk. Below this disk will be seen the compensating wheel which travels loosely upon an oblique shaft. This oblique shaft is geared to the intermediate shaft so that it revolves only when there is a movement of the gates. It is further provided with a square thread, as is also the compensating wheel. The object of this device is to avoid racing of the governor, and the principle is as follows: When the speed is normal the compensating wheel seeks the center of the disk, which is supported upon it, because this disk is constantly revolving with the cam. When a movement of the gates occurs the compensating shaft is revolved and the wheel travels along its shaft in such a direction that it will separate the cam from the tappet when the gate has been moved to that point which will give the correct speed, after the momentum of the machinery has been overcome. During this interval the disk returns the compensating wheel to the central position. This device can be made to properly compensate for any condition, as the time element can be varied, not only by varying the pitch of the screw, but also by varying the speed of the oblique shaft with a change of gears.

The governor shown is the largest and most powerful manufactured by the company. The friction wheel, 24 inches in diameter and 12 inches wide, is made with sufficient surface to transmit, if necessary, 5,000 foot-pounds per second to the turbine gates. All the gears are cut from the solid and have wide face and coarse pitch. The shafts are of ample size and are well supported in large bearings. The friction shaft, which is the only shaft that runs continuously, has ring oiling bearings, and from them there is a continuous supply of oil carried to the hubs of the pans, which are loose on the shafts.

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THE WESTINGHOUSE ELECTRO-PNEUMATIC RAILWAY CONTROL SYSTEM.

The system of multiple unit control used by the Westinghouse Electric & Manufacturing Company involves the use of compressed air for actuating the controlling apparatus, the compressed air mechanism being itself controlled electromagnetically; the exciting current for the magnets is supplied from a small storage battery. The motor controller is of the series-parallel type, and the electrical part of it is of the familiar arrangement consisting of a large drum, which makes the various circuit combinations for the propelling motors and a small one, which is used to reverse the motors. The main controller drum is operated by means of a step-by-step mechanism worked by a compressed air cylinder. Fig. 1 herewith is a diagram of the system and shows clearly the fundamental features. The pilot controller, or multiple control switch as the manufacturers prefer to call it, which is manipulated by the motorman, controls the admission of current to valve-actuating magnets, the pilot control circuits being carried throughout the length of the train. Each motor car is, of course, equipped with an electro-pneumatic controller.

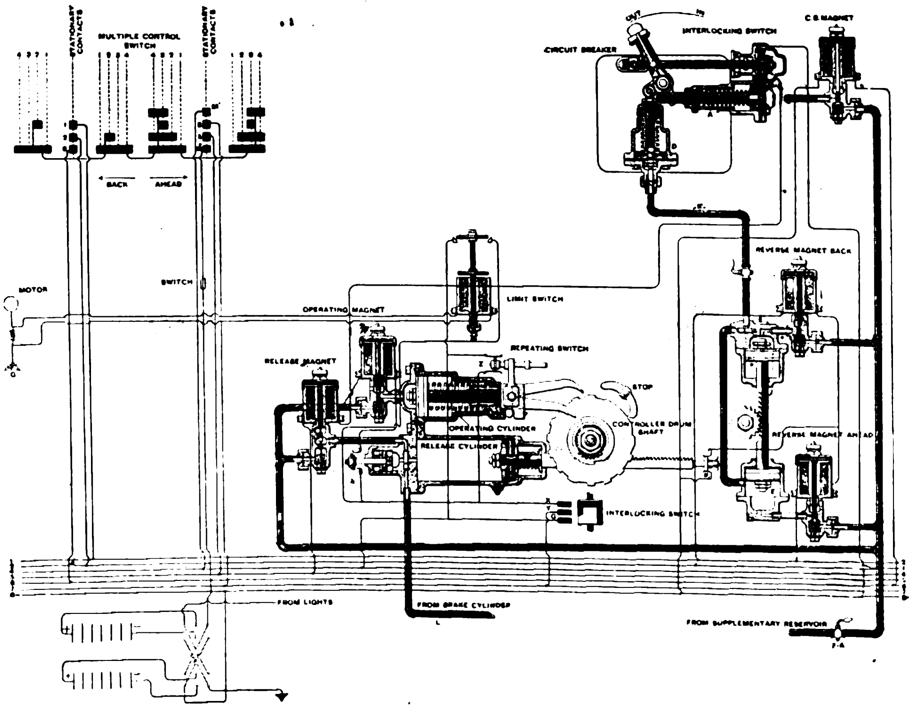

FIG. 1.—WESTINGHOUSE ELECTRO-PNEUMATIC RAILWAY CONTROL SYSTEM.

The direction in which the train is to be moved is determined by the two magnets in the right-hand part of the diagram, marked "Reverse Magnet Back" and "Reverse Magnet Ahead." The method of control is obvious; each magnet operates a valve admitting air to a pneumatic cylinder, and the pistons of the two cylinders are connected rigidly to a rack which meshes with a pinion on the shaft of the reversing drum. The main controller drum is actuated by a pawl on the end of the piston rod of the "Operating Air Cylinder." The controller is released by another cylinder located immediately below the operating cylinder in the diagram. The operation is as follows:

When the multiple control switch is moved to the first point, the battery circuit is completed through the circuit-breaker magnet which is shown in the extreme upper right-hand corner of the diagram. This magnet immediately opens the air valve, admitting air to the cylinder *A*, and the piston of this cylinder compresses a spiral spring, allowing the circuit-breaker to close. When the multiple control switch is moved to the second position, one of the reverse magnets is energized, which one depending, of course, upon the direction in which the multiple control switch has been thrown; at the same instant the "Release Magnet," shown in the central part of the diagram, is energized and closes the supply passage to the release cylinder and opens that cylinder to the atmosphere. The circuit-breaker magnet remains excited. The air which is admitted to the reverse cylinder (*E* or *E'*) passes from that cylinder, after setting the reverse drum properly, through the pipe connection *K* to the cylinder *D*, the piston of which forces in the circuit-breaker. Air is prevented from passing from one reversing cylinder to the other by means of a double-acting check valve located in the head of the reverse cylinder *E'*.

When the pilot switch is moved to the third position, current is supplied to the operating magnet through the repeating switch *Z*, the movable member of which is mounted on the end of the operating piston rod. The operating magnet admits compressed air to the operating cylinder and the piston rod is pushed forward, of course moving the main controller drum one notch and at the same time breaking the circuit of the operating magnet at the repeating switch *Z*. This allows the operating magnet to close the supply passage and open the exhaust passage of the cylinder, and the spring in the operating cylinder, of course, returns the piston to its original position. The repeating switch closes the operating magnet circuit again, and the operating cylinder, therefore, moves the controller drum over another notch.

This operation is repeated until the controller reaches the point of maximum speed with the motors in series. At this point the fingers *X* and *Y*, which are connected to the terminals of the repeating switch *Z*, are short-circuited by the contact segment on the interlocking switch, which prevents any further operation of the controller drum. Upon moving the multiple control switch handle to the next position, the connection between the contact, *Y*, and the repeating switch, *Z*, is broken, allowing the controller mechanism to resume operations and carry the controller drum up to the position of maximum speed with the motors in parallel. Here the interlocking switch short-circuits the fingers, *X* and *G*, stopping the reciprocating motion of the operating cylinder by closing the repeating switch.

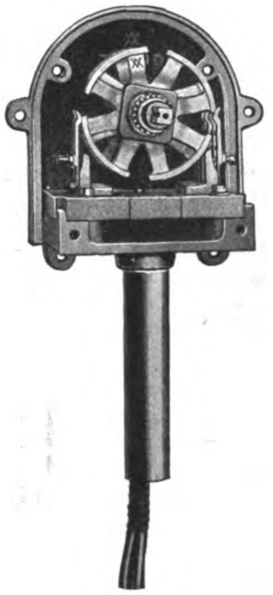

FIG. 2.—CONTROLLER.

In order to cut off the motors, the multiple control switch is brought back to the first position, opening the circuit of the release and operating magnets and thus throwing off the compressed air from the operating cylinder and turning it into the release cylinder, which throws the controller drum back to zero and at the same time closes the contacts at *g*, restoring the circuit of the reverse magnets, which circuit was broken, of course, as soon as the controller drum was moved from the zero position by the operating cylinder. The limit switch in the upper-central part of the engraving serves to short-circuit the repeating switch and thus stop the operation of the controller drum whenever the current through the motors exceeds a predetermined value, the winding of the limit switch magnet being connected in shunt to the field winding of one of the motors, as indicated in the diagram. The small switch, *h*, on the rear of the release cylinder, opens the circuit of the operating magnet as soon as air is admitted to the release cylinder, in order to guard against the possibility of conflicting action on the part of the operating and release cylinders simultaneously. Moving the controller handle to zero breaks the circuit of the circuit-breaker magnet, releasing the compressed spring and allowing it to open the circuit-breaker. The circuit-breaker is also automatic under excessive load, independently of the electro-pneumatic control.

S. K. C. REVOLVING-FIELD ALTERNATORS.

The Stanley Electric Manufacturing Company has brought out a line of revolving-field machines for supplying currents at the lower frequencies which have been so extensively adopted for heavy power plants. Fig. 1 herewith shows the two halves of the revolving field-magnet of a 2,000-kw. machine.' As the engraving shows, the field-magnet cores are bolted to the frame of the flywheel structure and provided with pole-shoes which hold the coils in position. The magnet cores are of cast steel and the pole-shoes are built up of laminations.

The pole-faces are beveled heavily at the edges, so as to permit the use of simple straight armature slots—that is to say, slots of the same width throughout their depth, in contradistinction to the overhanging tooth construction. The field magnet is usually wound for 125-volt exciting current, and in special cases 250 volts are used, but this is the highest e.m.f. allowed for the exciting current.

In the very large machines, such as the one just referred to, both the armature structure and the field-magnet are divided, the division of the armature being horizontal. In the machines of moderate output, the armature core is assembled within an iron housing cast in a single piece, as indicated in Fig. 2, which shows the armature of a 600-kw. machine. As the engraving clearly shows, the winding is of the straight-out or barrel type. The armature punchings are held in the housing either by bolts which pass through lugs on the punching, and therefore do not cut the magnetic flux, or by dovetails and keys. Ventilating ducts are provided at short intervals across the core, and the winding is held in place by wedges. In fact, the construction conforms almost exactly to modern practice in direct-current armature construction, the only difference being that the active face of the armature is, of course, on the interior of the core ring, the armature being stationary. The armature terminals are carried to a marble terminal-board mounted on the frame of the machine, or, in the case of the machines for very high potentials, the terminals are directly connected to leads from the bus-bars, the conductors being, of course, heavily insulated at all points. The collector rings which receive the exciting current are of iron and the brushes are of carbon.

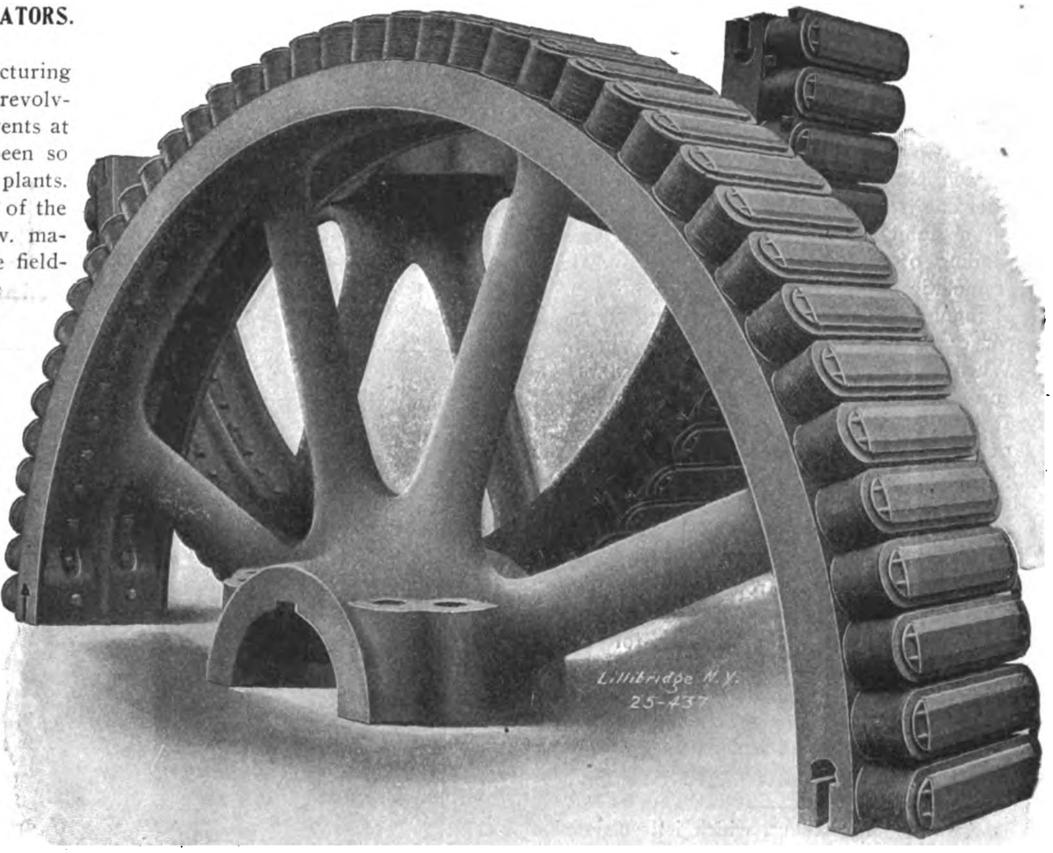

FIG. 1.—FIELD OF 2,000-KW. S. K. C. REVOLVING FIELD GENERATOR.

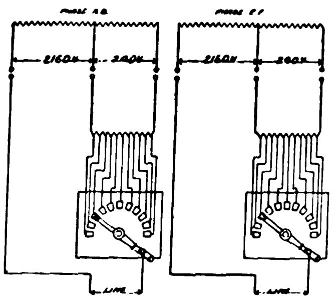

FIG. 3.

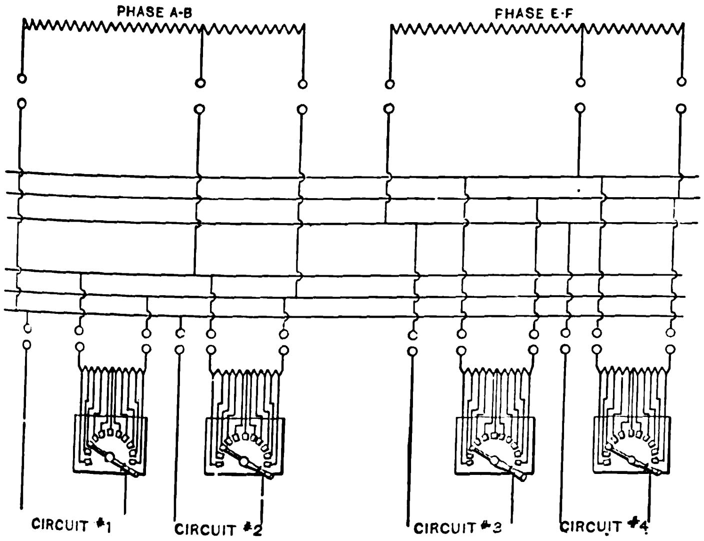

FIG. 4.—PHASE REGULATION BY AUTO-TRANSFORMERS.

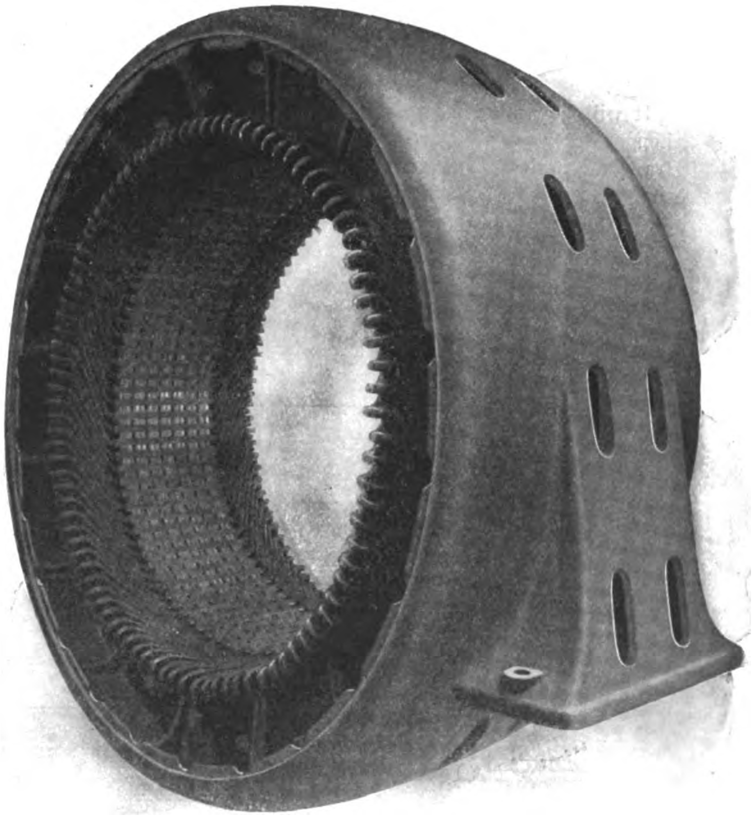

FIG. 2.—ARMATURE OF 600-KW. S. K. C. REVOLVING FIELD GENERATOR.

The belt-driven machines of moderate size are built with the exciter mounted on a bracket on the journal pedestal, the armature of the exciter being located on an extension of the alternator shaft.

On two-phase machines, the regulation of each phase e.m.f. independently of the other one is accomplished by cutting in and out a number of turns in the armature winding of each phase, as indicated diagrammatically by Fig. 3. The proportion of regulation is usually between 10 and 15 per cent. of the total e.m.f. of the phase. When several circuits of different lengths and carrying different loads are supplied from the same phase, so that the regulation of the phase e.m.f. at the machine cannot give satisfactory results, it is the practice of the Stanley Company to use adjustable auto-transformers, each connected between one terminal of the winding of each phase and a tap brought out from an intermediate point in the winding, as indicated in Fig. 4. This diagram shows connections for two circuits supplied from each phase, each circuit being individually regulated by means of its auto-transformer.

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THE PEERLESS AUTOMATIC STOKER.

An automatic stoker, which it is claimed will burn soft coal without yielding any smoke, has recently been devised by F. Girtanner. The stoker and furnace are manufactured by the Peerless Automatic Smokeless Stoker Company, of New York City, and are shown by Fig. 1 herewith. Fig. 2 gives a front view of the stoker in operation.

It will be noticed there is an adjustable hopper filled with soft coal, and below a traveling endless grate feed-apron substantially air-tight, which is operated at an intermittent speed by a ratchet movement that carries forward from beneath the bottom of the coal heap a fixed amount of fresh coal to the interior.

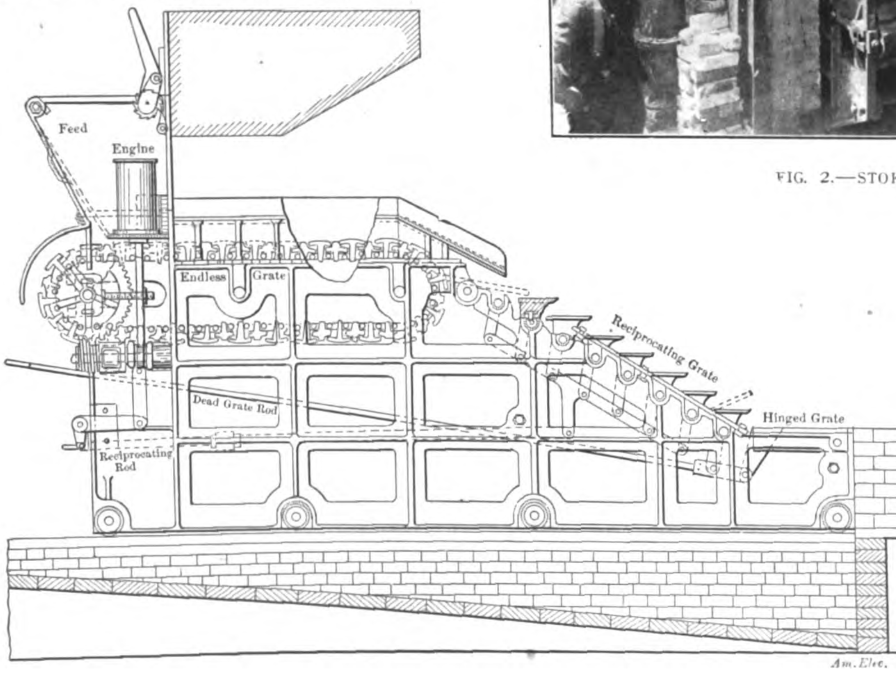

FIG. I.—PEERLESS AUTOMATIC STOKER.

It will be observed that as the coal is drawn in at the front no air is admitted. At this point the reflected heat from an intense fire at the rear bakes or cokes the coal as it enters the chamber, driving out the gas as in the process of gas manufacture, which, as it comes in contact with the fire beyond, is ignited and complete combustion is secured; as the coked coal is carried further to the rear, it is said to burn on the steep-inclined grate in a smokeless flame, and is maintained at an intense heat by the draft of air passing through it; thus the full heat-giving efficiency of the fuel is said to be obtained.

The inclined grate hinged at one end is occasionally swung back and forth automatically by a lever operated in connection with the feeding mechanism at the front and serves to slice or break up the fire, permitting a free circulation of air through it. The ashes fall from the inclined grate to a rear platform grate hinged at its rear, whence the ashes are easily dumped into the ash pit below.

The practical efficiency of the stoker and smoke consumer over the ordinary method of hand firing is shown in the accompanying figures taken from tests performed on boilers in the works of the Standard Malt and Hop Brewing Company, at Guttenburg, N. J., one boiler being fitted with a stoker and the other without. The same grade of coal was used in both tests.

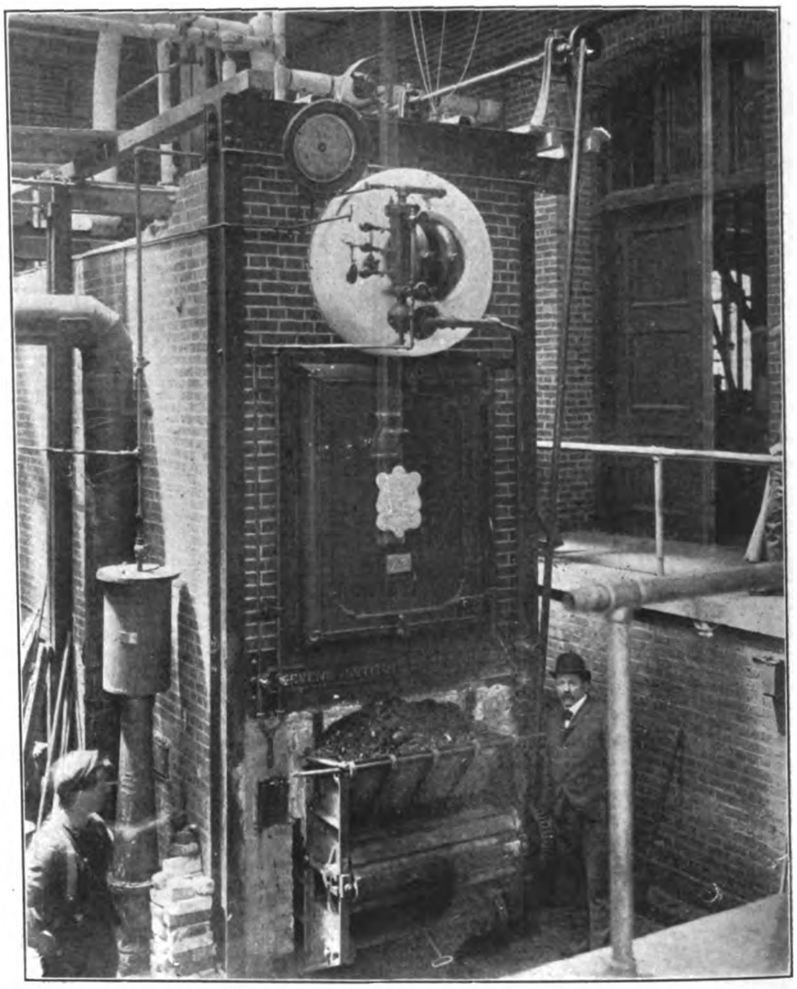

FIG. 2.—STOKER IN OPERATION.

	By Automatic Stoker.	By Old Method.
	lbs.	lbs.
Water Evaporated	53,513	50,508
Amount Coal Burned.........	5,821	6,801
Water Evaporated per lb. coal..	9.20	7.36
Water Evaporated per lb. coal, 212 degrees Fahr...........	10.20	8.24
Water Evaporated per lb. combustible, 212 degrees Fahr...	12.05	9.95
Ashes and Clinkers............	480	1,123

This test showed a net saving of 20 per cent., besides giving smokeless combustion, as against combustion attended with dense black smoke with the ordinary method of firing. The stoker is said to have been given exhaustive tests at Stevens Institute, Hoboken, N. J., and yielded excellent results.

New Apparatus and Appliances

LARSEN CABLE PAINTER.

In many cases where it has been attempted to paint an overhead cable with some preservative compound, the method pursued has been very slow and often accompanied with more or less risk and not a little inconvenience. To overcome these difficulties and at the same time to give a more rapid method of accomplishing this result, C. Larsen, of Crockett, Cal., has devised the instrument shown by Fig. 2 herewith, which should be of interest to those who have occasion to protect cables and wires after they have been strung, with a preservative compound. Fig. 1 shows the construction of the instrument. It consists of a cylindrical tank with a slot cut in its entire length, as shown. The tank is moved to its position, the cable being placed in the slot. The portion shown to the left is then locked in position and the preservative poured into the spout in the top. The surfaces between which the cable passes are lined with a packing which distributes the preservative over the cable. A weight is suspended from the bottom of the tank in order to keep the same in an upright position. Grooved wheels keep the tank centrally on the cable and carry its weight, and at the bottom, near the front end, is an eye for attaching a cord by means of which the apparatus is pulled along the cable.

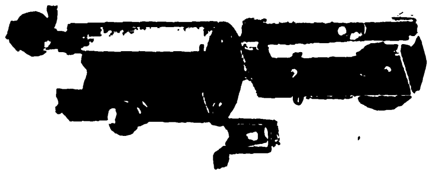

FIG. 1.—DETAILS OF CABLE PAINTER.

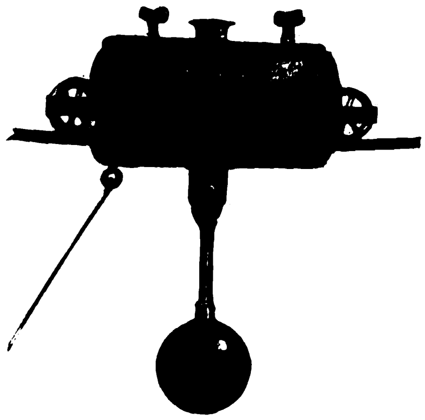

FIG. 2.—LARSEN CABLE PAINTER.

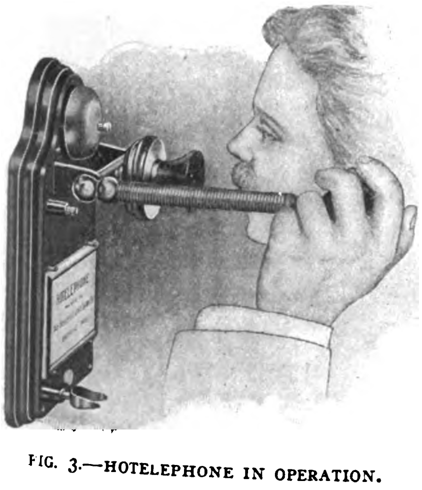

FIG. 3.—HOTELEPHONE IN OPERATION.

THE HOTELEPHONE.

The Holtzer-Cabot Electric Company, of Boston, Mass., is introducing the unique telephone set shown by Fig. 4 herewith. It is known as the "Hotelephone," and is intended primarily for hotel service, being admirably adapted for use in guest rooms. It differs widely from any other telephone set on the market and possesses numerous advantages in operation. The instrument is equipped with a bipolar watch case receiver, with hard rubber shell and with a granular carbon transmitter, all of which are arranged somewhat after the style of the familiar microtelephone. The receiver is attached to a flexible arm connected with a bar on which the transmitter is mounted in such a manner that raising the receiver to the ear automatically brings the transmitter mouthpiece directly opposite the mouth of the speaker. Dropping the receiver has the same effect as replacing the ordinary telephone receiver on the hook. The base is cast in one piece and finished in black enamel. To it is attached a card holder for a directory of signals, etc. All of the contacts and connections, being underneath the base, are dust proof, but are easy of access through an opening under the card holder. In using the instrument the speaker is compelled to talk into the transmitter, this insuring a good transmission, and since the granules of the transmitter are agitated every time the receiver is dropped, packing is prevented and the objection to the granular carbon transmitter overcome. The many unique features in its construction will doubtless suggest its use in other places where the ordinary form of telephone is not entirely satisfactory. There is an automatic adjustment of the receiver and transmitter to persons of different heights.

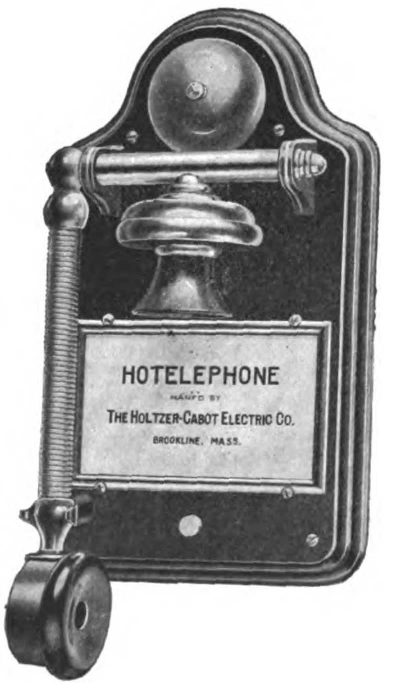

FIG. 4.—HOTELEPHONE.

ELECTRIC SPEED CONTROLLER.

The trend of modern practice is to control all parts of a plant from some central point. The Lombard Governor Company, of Boston, Mass., recognizing this fact, has recently made an improvement in its governors which adapts them to this condition, and since the governors control the water-wheels and, consequently, the generators attached thereto, this improvement enables the attendant in charge to start up, stop, or alter the speed at will of any or all of the machines under his supervision.

The apparatus for accomplishing this result is extremely simple, consisting merely of two small push buttons on each generator panel on the switchboard or pilot switchboard, which connect through three wires to a little electric motor. This motor, through suitable mechanism, acts upon the valve stem of the governor in such a manner as to lengthen or shorten the connection between the centrifugal balls and the valve itself. The part of the device attached to the governor is shown very clearly in the illustration.

A small motor of the form commonly used to drive fans is mounted upon a bracket which is clamped to the regulating valve of the governor. This motor has the capacity of about 1-16 of a horse-power. Upon the armature shaft is mounted a small worm driving a worm gear on a vertical pinion shaft. This pinion transmits rotary motion to a gear which, being threaded through its hub, acts as a right and left coupling to draw together or push apart the two portions of the valve stem upon which it rotates. The pinion which drives the gear is long enough so as not to interfere with the up and down travel of the gear, and therefore the control of the valve by the centrifugal balls is not affected in any manner.

The method of operation is apparent, the small motor serving only to shorten or lengthen the valve stem. Heretofore in

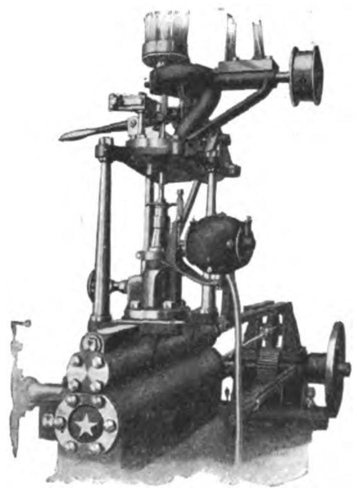

FIG. 5.—SPEED CONTROLLER.

bringing generators into synchronism it has usually been necessary for one man to watch the synchronizing lamps while an assistant stood by the side of the governor, gradually changing its speed according to signals received from the switchboard. With this device the services of the man at the machine are not required, for the man at the switchboard with his fingers on the two push buttons can raise or lower the speed of the generator, which is to be thrown in multiple with others, without taking his eyes for an instant away from the synchronizing lamps or corresponding device. Thus there is not only a saving of time but also a more certain action. The gear connections from the motor are such that a delicacy of adjustment is possible. The motion is said to be positive and there can be no change except by the will of the operator. Where alternating current generators are in use, current for the proper operation of the device is generally obtained from an exciter circuit. Where it is desirable to use an independent source of energy, special motors are provided, to be run upon a primary or secondary battery circuit. There is said to be no difficulty in operating the device with two cells of common dry batteries. The distance between the controlling push buttons and the governor need not be considered as a drawback. If the space is very great, *e. g.*, several miles, telegraph relays are installed near the governor. Telephone or telegraph wires may thus be used, a suitable switch being arranged to throw them out of service for a few moments while synchronizing. Thus in electrical distribution systems the speed at the generating stations, may be controlled from the central distributing station.

Under certain circumstances, although not generally, it is desirable that a signal should be sent back from the governor to indicate the change in length of the valve stem, and thus indirectly the change in speed which takes place. An extra attachment can be furnished which will do this, and will also permit the operator to change the speed by a step-by-step adjustment of a predetermined amount, *e. g.*, ½ per cent. for each push of the button.

PUSH-BUTTON SWITCH.

The Marshall-Sanders Company, of Boston, Mass., is placing on the market the push-button switch shown by Fig. 6 herewith, and which is claimed to possess a number of distinctive features. The switch mechanism is entirely encased in one piece of porcelain. The face plate is an hydraulic forging made to the standard of the National Electrical Contractors' Association, 2½ x 4¼ inches, and gives a high finish. All the parts of the switch mechanism are said to be machined, thereby rendering the action easy and certain. Flexible tungsten steel springs permit the combination of a strong and quick break at the contacts with an easy and flexible push of the buttons. The switch has ample room for drawing in and connecting wires and will fit any style of conduit box.

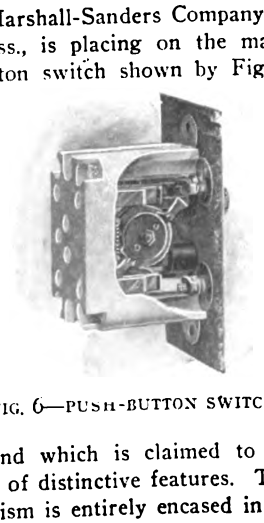

FIG. 6—PUSH-BUTTON SWITCH.

ALPHADUCT FLEXIBLE CONDUIT.

The Alphaduct Manufacturing Company, of New York City, has brought out a fireproof fiber conduit, known as Alphaduct, which is said to be meeting with marked favor. Fig. 7 herewith shows a piece of this conduit with portions cut away so as to show the different parts which go to make up the complete conduit. Beginning at the top of the engraving, the inner lining is shown. This is of heavy fire-proof canvas and is covered with a slow-burning flexible weather-proof compound over which is spirally wound hard-twisted cable cord. The interstices between the cord are then filled with a special compound of cement, the whole forming a wall which, it is claimed, will not carry fire from any outside connection. Over this is a protecting jacket of cotton rendered fire-proof, then braided and finally coated with a slow-burning flexible weather-proof compound and dusted with a powder to prevent adhesion. The interior of the conduit is the smooth hard finish of the cotton duck, which is very easy to "fish," but to make it perfect in this respect it is dusted with powdered soapstone, which acts as a lubricant, rendering the surface very smooth for the wire to pass by.

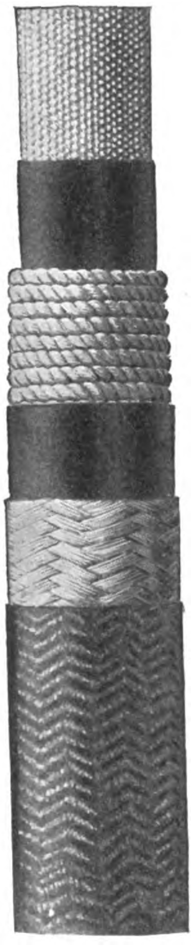

FIG. 7.—ALPHADUCT.

A NEW TELEPHONE RINGER.

The accompanying illustration, Fig. 8, shows a new telephone ringer recently placed on the market by the Stromberg-Carlson Telephone Manufacturing Company, of Rochester, N. Y., and Chicago. The ringer is said to embody new and simple features in the matter of adjustment. The engraving shows a view of the armature end of the ringer, which is almost self-explanatory, as regards the manner in which adjustment is made. It will be observed upon examination that a screw passes through the permanent magnet, the armature and the armature frame support, and is threaded into the armature yoke. By turning this screw in one direction a shoulder on the screw is pressed against the frame that supports the armature, and this being made of spring steel is pressed downward, thus bringing the armature nearer the cores. Turning the screw in the opposite direction allows the distance between the cores and armature to be increased by the action of the spring. This adjustment is very simple and it is evident requires the turning of only one screw, which may be done as easily after the ringer is mounted on a telephone box or base as before.

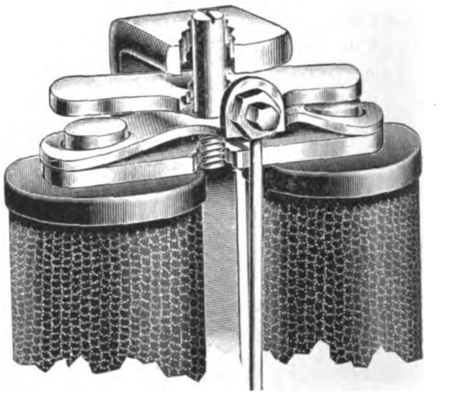

FIG. 8.—TELEPHONE RINGER.

THE WALRATH GAS ENGINE.

Fig. 9 herewith shows a 3-cylinder 100-h.p. Walrath gas engine manufactured by the Marinette iron Works Manufacturing Company, Marinette, Wis., and direct-connected to an 80-kw. generator. The engine is built in three styles, having one, two and three cylinders, and all are of the vertical type. The three different styles embody the same mechanical construction, and hence any reference made to the working parts of one will explain relative parts of the others; they differing only in the number of cylinders. The engine operates on the four-cycle principle. The base is cast in one piece and is accurately bored to receive the cylinder and cam shaft bearings. The main bearings are separate castings from the base and are all turned up together on an arbor and fit in a corresponding part of a circular bore made to receive them in the base. They are removable without disturbing the crank shaft, and are lined with babbitt metal. The cylinder or cylinders, as the case may be, are bolted to the top of the base and fit into a bore made to receive them. Being of the vertical type, they are free to expand without the objection of overhanging. They are cast of special close-grained iron and are water-jacketed. Each cylinder is cast separate, so that in case any damage occurs to one, it will not be necessary to obtain an entirely new set of cylinders. The cylinder head is fastened with studs, and in it are placed the cages which contain the valves. The head is easily removable without disturbing any part of the engine or piping. The valves are of the well-known poppet type, and are two in number, one for the inlet or explosive mixture, and the other for the exhaust. They both have a positive lift and work vertically. On all sizes, above and including 10 horse-power, both valves are placed in cages which fit into the cylinder head. The joint between the cages and the head is ground, so that either valve may be easily removed, and this without breaking any water joints or gaskets. The valves being in and extending through the head, make it possible to do away with any pockets or recesses in the combustion chamber. The pistons are of the open trunk type, and are very long, giving an abundance of surface in order to minimize the wear on the cylinder and pistons. It is kept tight by six snap rings of cast iron, and is said to require no adjusting. The connecting rod of the engine is a steel forging supplied with bronze boxes at both the cylinder and wrist-pin end. The wrist pin is firmly held in position, and is of case-hardened steel. Instead of balancing by casting balance weights in the flywheels, the balance weights are fastened directly to the crank-shaft, thereby being brought as near as possible to the parts to be counterbalanced. The starting device consists of an air pump and tank, the pump being generally driven from the crank-shaft. The starter valve is a type of piston valve which is operated by a cam, and by means of ports supplies air from the tank to the cylinders. The valve then opens communication between the cylinder and the atmosphere so that the air is exhausted from the cylinder after performing its work. When the engine comes up to speed with its own fuel the compressed air is shut off. The fuel used is natural or artificial gas or gasoline. The igniter is compact in form and is secured in place by two studs. The governor is of the well-known fly-ball type, driven by bevel gears, and regulates the amount of explosive mixture required for each impulse. The method of governing gives an impulse every second revolution for the one-cylinder type, every revolution in the two-cylinder type and every two-thirds of a revolution in the three-cylinder type, irrespective of the load.

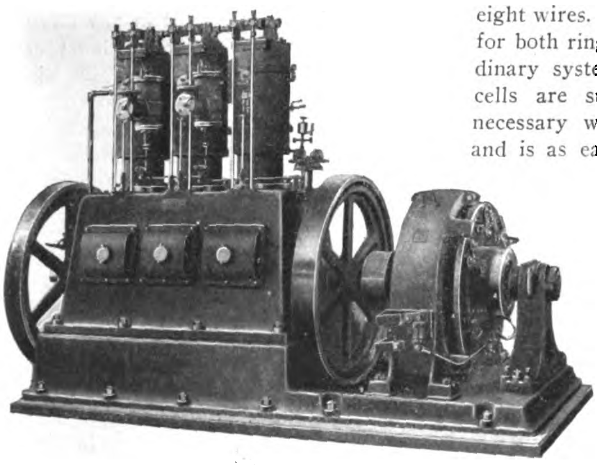

FIG. 9.—WALRATH GAS ENGINE.

MONOPLEX INTERCOMMUNICATING TELEPHONE SYSTEM.

The Atwater Kent Manufacturing Works, of Philadelphia, manufacturers of the compact little telephone outfit known as the Monoplex, have developed a line of intercommunicating systems that embody the chief feature of the Monoplex instrument, namely, simplicity. The selective signalling apparatus is of the push-button type. Fig. 10 is a diagram of the all-around intercommunicating and selective ringing system. The number of wires needed on this system is three plus the number of instruments, so that a system of five stations, for example, would require eight wires. A single central battery is used for both ringing and talking, and for an ordinary system three dry cells or four wet cells are sufficient. The impedance coil necessary with this system is inexpensive and is as easily connected to the wires as would be a single cell of battery. The system illustrated by Fig. 11 is non-selective, but universally intercommunicating. It requires but four wires, and a single push-button at each instrument rings all of the bells on the system. By means of a code of signals any one of the different stations may be called; for factory use it is much better to use a code of signals to call the different men, the person called going to the nearest telephone. A central battery of two or three cells and an inexpensive impedance coil are used. Fig. 12 is a diagram of a radial system in which there are a main central instrument and a number of outlying stations, all connected to the central one but not to each other. Each station can call up and talk to central, and central can call them up individually, but the stations cannot call up and talk to each other. A system consisting of a central and four outlying instruments, for example, would need six wires. If the stations lay in opposite directions three wires would go to each. The battery is centrally located an' no impedance coil is used.

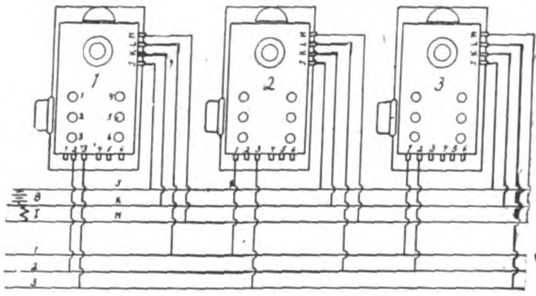

FIG. 10.—MONOPLEX TELEPHONE SYSTEM.

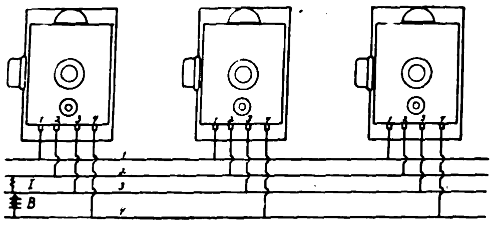

FIG. 11.—MONOPLEX TELEPHONE SYSTEM.

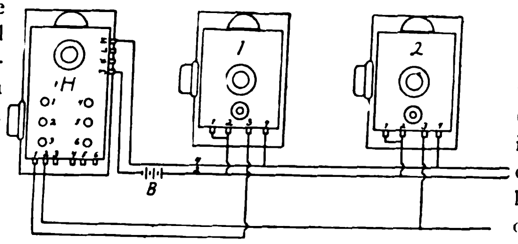

FIG. 12.—MONOPLEX TELEPHONE SYSTEM.

ELECTRIC HEATER SWITCH.

The Hart & Hegeman Manufacturing Company, Hartford, Conn., has just brought out a new switch for use in conjunction with electric heaters, which possesses several novel points of merit. Fig. 14 herewith gives a view of the switch with the cover removed, and Fig. 13 shows it complete with the cover. The switch is intended to cut in or out of circuit one, two or three sections of the heater and will break currents as high as 35 amperes on a 500-volt circuit. The handle of the switch is provided with a finger which points to the number of sections of the heater which are in circuit, or to the word "off" when the heater is cut out. In addition to this indication the spindle carries an indicating dial just beneath the surface of the switch cap, the marks on the dial showing through a small aperture in the cap as in the case of the ordinary indicating snap switch. The most unusual feature of the switch is that the handle may be turned in either direction, the contacts giving a snap break both ways. The arrangement of the jaw and contact clips is similar to that in the well-known standard type of Hart & Hegeman switch.

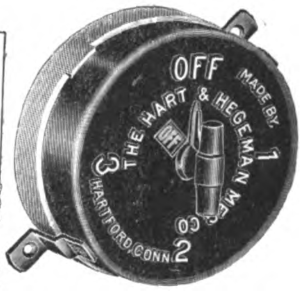

FIG. 13.—HEATER SWITCH.

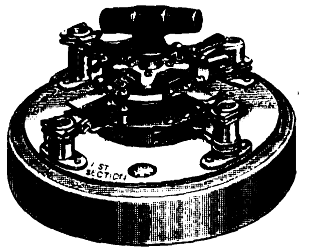

FIG. 14.—HEATER SWITCH.

THE ELECTROTONIC BATTERY.

The compact instrument shown by Fig. 15 herewith and known as the "Electrotonic" battery is manufactured by the Swan Electric Manufacturing Company, of New York City. It is intended to serve as a medical induction coil receiving current from a special semi-plastic cell. It is eight inches long, two inches wide, and weighs thirteen ounces. The coil is bolted to the cell through two nickeled strips which, besides supporting the inner parts, act as conductors of electricity. A circular hard-rubber top is fastened to the induction coil on which the connectors and switch are placed. The vibrator is situated at the base of the coil and can be easily adjusted without removing the cell from its fastenings. The cell is interchangeable and is readily attached or detached by two thumb screws. The whole is enclosed in a frosted aluminum case, the two electrodes, when not in use, fitting over the ends and acting as covers. Should the switch be left inadvertently in the operating position, the replacing of the cover causes the switch to be moved to the "off" position, so that the battery will not be run down through carelessness on the part of the operator. Accompanying the outfit are the necessary flexible cord conductors and electrodes.

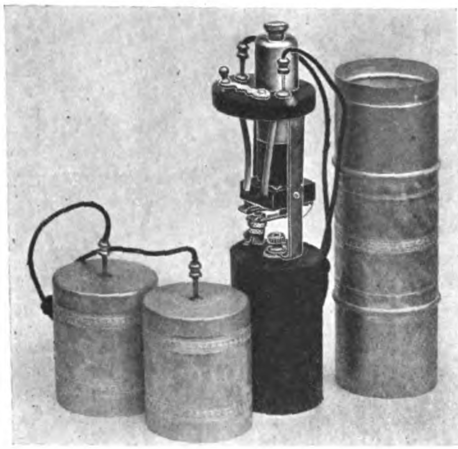
FIG. 15.—ELECTROTONIC BATTERY.

NEW PORCELAIN ELECTRICAL SPECIALTIES.

The accompanying illustrations show a number of "Norbitt" porcelain electric specialties brought out by the Crouse-Hinds Electric Company, of Syracuse, N. Y. The temporary socket shown by Fig. 16 can be used for decorative purposes with standard lamps and standard stranded wire. The electrical connections are made without removing or affecting the insulation of the wire. The socket is easily and quickly installed before or after the wires are in place, and is practically weatherproof. The adjustability of the appliance permits the use of any size of conductor from No. 14 to No. 4. The electrical and mechanical construction is most substantial and the socket is used on 250-volt circuits in multiple or on 600-volt circuits in series. The illustration shows the actual size of the socket. The fuseless cord rosette for moulding is made in two pieces, a cap and base, shown by Figs. 17 and 18 respectively. The base is fastened to the moulding with one screw, which passes through the center. The initial electrical connection to the circuit wires is easily and securely made by means of two binding screws on the top surface of the base. The cap is permanently secured to the base by two screws which serve the double purpose of fastening the cap in place and completing the electrical connections. These two screws are so constructed that it is impossible for them to drop out during installation. The cap covers the base completely and is placed in position only after all other work is completed; the base being installed while the rough work is in progress. The flexible lamp cord is attached directly to the clips in the rosette cap and not to the base, thus rendering it possible to prepare flexible cord drops complete at workshop for installation at the convenience of wiremen, and also allowing for necessary repairs to drops without disconnecting the line. A square cut in the cap of the moulding is all that is required when installing the rosette. The conduit fixture is shown by Fig. 19. This is an entirely new departure in conduit work and embodies all of the enclosed contact features of the fuseless fixture rosette for moulding. The fixture is not electrically connected in any way to the conduit system. The fixture is screwed into the brass bushing in the cap, the wires being attached to clips in the rosette cap and not to the base. The threaded cap permits the use of a goose-neck fixture. The weatherproof socket shown by Fig. 20 has the following special features: The lead wires are fastened to the contact parts in a new and approved manner without the use of solder, thus making it possible for the workman to easily repair, renew or alter the length of lead wire. A special fixture cap is obtainable for making a bracket weatherproof socket for outdoor fixture use, and in using this special cap, all twisting off wire, heretofore experienced in similar appliances, when screwing sockets into bracket is avoided. The illustration shows the various parts of the appliance which is furnished only with a shade holder groove.

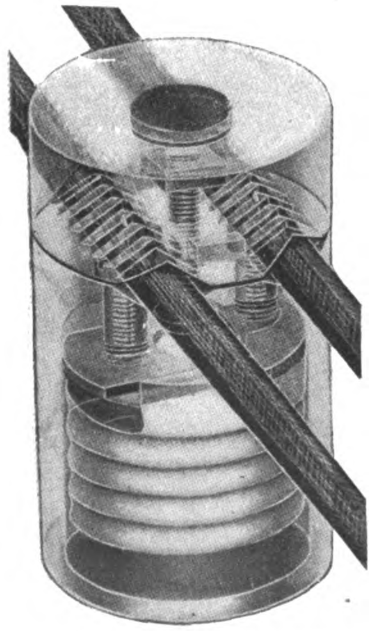
FIG. 16.—TEMPORARY SOCKET.

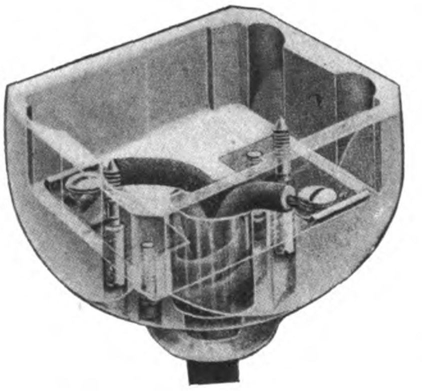
FIG. 17.—FUSELESS FIXTURE CAP.

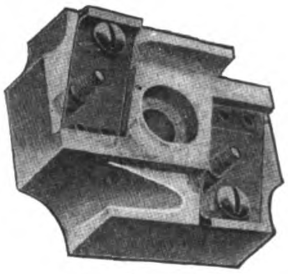
FIG. 18.—BASE.

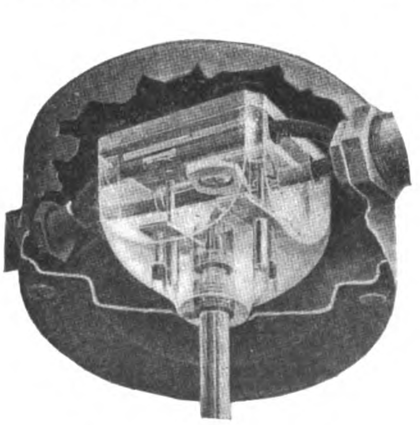
FIG. 19.—CONDUIT FIXTURE.

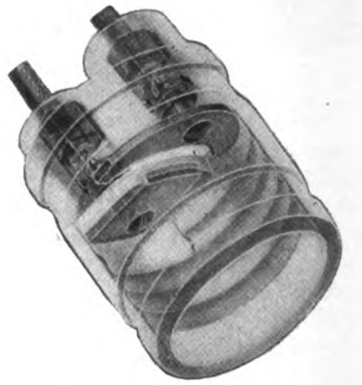
FIG. 20.—WEATHERPROOF SOCKET.

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DRY BATTERY TESTS.

The accompanying charts have been plotted from the results of some interesting tests made by Mr. Geo. T. Hanchett, with the No. 5 New Standard dry battery, manufactured by Wm. A. Roche, of New York. The weight of this cell is 2 pounds. The internal resistance averages about .12 ohm, the rated voltage is 1.52, and on short-circuit the cell will give from 15 to 18 amperes.

The curves of Fig. 1 indicate the performance of one of these cells discharging through a resistance which was varied so that the current was always 2 amperes. It will be noted that the starting e.m.f. with resistance in circuit was 1.18 volts, and that it required nearly 3 hours and 10 minutes to reduce the e.m.f. 0.3 volt, the voltage falling off almost uniformly with respect to time. On releasing the cell from the test, the voltage rapidly recovered, and in 12 hours the open-circuit voltage had returned to 1.2

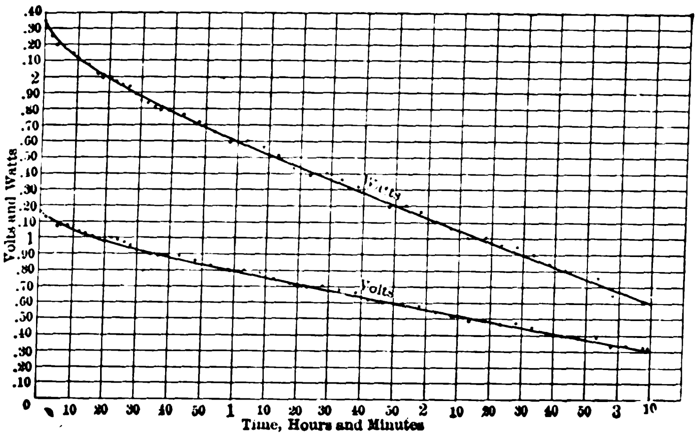

FIG. 1.—DRY BATTERY CURVES.

Fig. 2 gives the discharge curves of the cell through a constant resistance of .179 ohm. The current started at 5 amperes and at the close of the test was slightly over 2 amperes, a little over 2½ hours being required to reduce it to this value. The voltage of the cell on open circuit quickly recovered within 12 hours to 1.2 volts as in the former case. The watt hours per pound of cell on a 3-hour test was a little over 2.3.

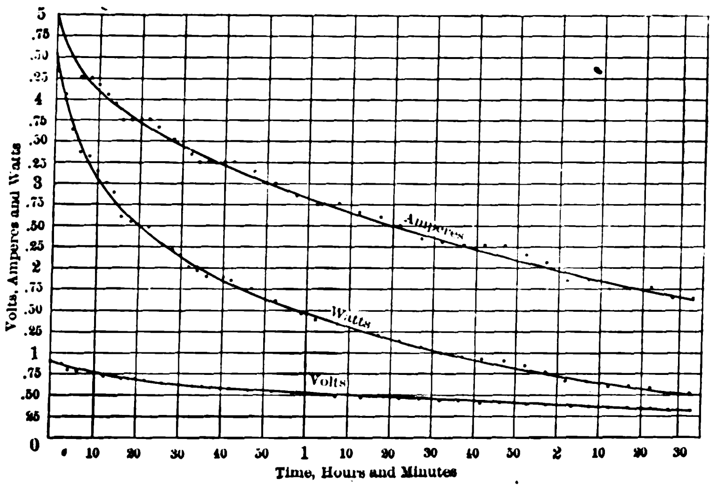

FIG. 2.—DRY BATTERY CURVES.

The curves of Fig. 3 are interesting as showing the behavior of the cell on a heavy short circuit and its subsequent recovery. The cell was short-circuited through .056 ohm, and starting with 10 amperes, the current fell off until after 2 hours and 15 minutes it had been reduced to a little below 2 amperes. On releasing the cell from its load, the open circuit e.m.f. almost immediately jumped to .7 of a volt, and after that by slower increments it rose, within 1 hour and 40 minutes, to .965 volt. This curve should be of interest to those who employ dry cells for the purpose of bell and telephone work. It shows that such a cell could endure a very severe short circuit and almost immediately recover sufficient voltage to work any ordinary apparatus to which it might be connected.

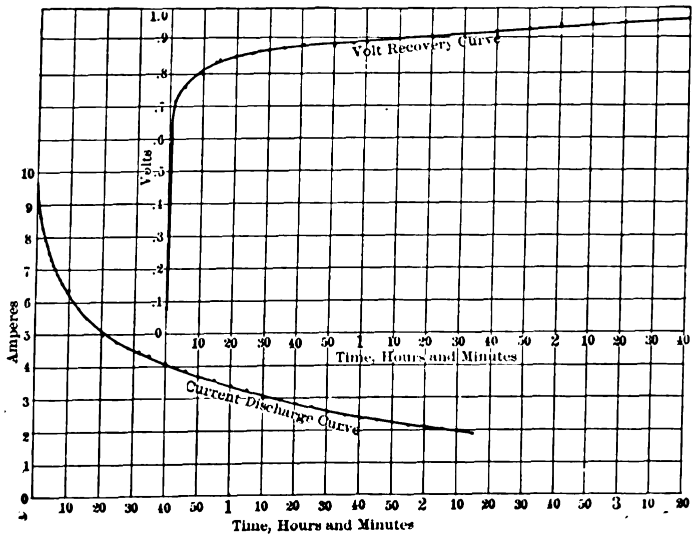

FIG. 3.—DRY BATTERY CURVES.

In all three of these tests the voltage recovery was very prompt, and is notable in view of the fact that these cells are intended for intermittent work. In a subsequent test made with this type of cell on an interrupted circuit, conditions that would obtain in automobile work being duplicated, the results were very satisfactory. The cell was first tested with a commutator in circuit, which closed the circuit one-thirtieth of the time. The cell when operated under this interrupted load ran for 3 hours and 25 minutes with rests between each hour period. The current was taken with the commutator at rest both before and after the test, as was also the open-circuit voltage. It was found that the current fell almost uniformly from 6.2 amperes. to 5.2 during the period of the test, the open-circuit voltage falling proportionately.

Finding that this arrangement would make the test unduly long, the commutator was changed and another was substituted which closed the circuit one-quarter of the time. This test extended over a period of 28 hours of running and 69 hours 26 minutes in rests, these rests being divided up at approximate hour intervals, the aim being to duplicate automobile conditions as nearly as possible. On the start of this second test the battery was able to force 4.2 amperes through its circuit. At the close of the test it was able to force 1.2 amperes through the circuit, the capacity for delivering current falling off practically uniformly throughout the run. At the close of the test the cell showed a strong tendency to recover its voltage and current-producing capacity.

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NEW BOOKS.

Proceedings of the National Electric Light Association. Twenty-fifth Convention. Published by the Association. Cloth; 720 pages, 6 ins. x 9 ins. Price, $2.50.

This is the usual annual publication of the Association and contains a report of the convention held last May at Cincinnati. In technical merit, however, it far surpasses any *Proceedings* hitherto published, the Cincinnati convention having been conspicuously the best one ever held by the Association. Probably the most useful portion of the book will be the Question Box report, which covers an enormous range of thoroughly practical topics.

Design of Dynamos. By Silvanus P. Thompson. New York: Spon & Chamberlain. Buckram; 253 pages, 6 x 9 ins.; 100 illustrations; numerous tables. Price, $3.50.

This is the latest of Prof. Thompson's works, and like his previous productions it is masterly and exceptionally clear in exposition. The author begins by defining magnetic terms and explaining the modern practice of calculating the excitation required for a magnetic circuit on the basis of ampere-turns per inch of length, instead of permeability, which might be considered superfluous by experienced engineers. The succeeding subject matter is nearly all "meat," however, and will undoubtedly be valuable to designers of limited experience, and of much interest to those of wider experience. There are several inconsistencies and one or two errors in formulas, which, unfortunately, cannot be detected by inspection, but are developed only by proving the correctness of the formula by computation. Again, some of the material is rather academic, as for example, the discussion of space factor in an armature slot and the recommendations as to calculating the saturation curve of a dynamo, which feat is utterly impossible of accomplishment unless one has previously built a machine having exactly the same magnetic constants. These drawbacks, however, are heavily overshadowed by the great merit of the book as a whole. The author has not attempted to lay down ridiculous inflexible rules by which to grind out designs *a la* sausage machine, but gives the methods of the best designers and cites many illuminating examples of their work.

Electrical Engineer's Pocket Book. (Third Edition.) By Horatio A. Foster. New York: D. Van Nostrand Company. Flexible leather; 987 pages, 4 ins. x 7 ins.; numerous illustrations. Price, $5.00.

This edition of Mr. Foster's excellent book does not contain any additional material as compared with the previous edition—in fact, it would be rather difficult to suggest anything legitimately belonging in such a book that has not already been included. The author has endeavored to weed out all of the typographical and other errors contained in earlier editions, and has succeeded so far as the reviewer has been able to check up. The book contains a vast amount of valuable material, and is cordially commended by the reviewer.

Handy Electrical Dictionary. By W. L. Weber. Chicago: Frederick J. Drake & Co. Soft leather; 224 pages, 2½ ins. x 6 ins. Price, $1.

Had the compiler of this little book conferred with anyone familiar with the principle of indexing, the value of the book would have been considerably greater than it is. The selection of subject words is crudely done, but the definitions are, in the main, accurate, although a few appear to be prepared with a view to masking a haziness on the part of the compiler as to the exact meanings. Thus, "Actual Efficiency.—Efficiency answering commercial purposes," while not particularly misleading is certainly not likely to satisfy one's thirst for information. First, no such term as "actual efficiency" is recognized in engineering work; secondly, it means absolutely nothing as it stands, because there are several kinds of efficiency all of which are "actual"; thirdly, there is no kind of efficiency that is considered as "answering commercial purposes," only specific degrees of commercial efficiency being thus definable; lastly, "efficiency" and not "actual" is the subject word of the term, which therefore should have been put with the other efficiencies in the E's, if it were fit to be put in the book at all. The reviewer might go on at wearying length pointing out failures to give clean-cut definitions or to classify terms in proper alphabetical order, but the example selected is sufficiently typical. It is regrettable that these deficiencies in the book exist; the idea is a most excellent one, and the publishers have done their part splendidly. If the compiler, however, will accept well-meant and friendly advice, he will seek experienced aid and revise his work at once.

Civil Engineer's Pocket Book. By John C. Trautwine. Eighteenth edition. New York: John Wiley & Sons. Morocco; 1,100 pages, 4 ins. x 6½ ins.; illustrated. Price, $5.

Comment on the general character of this well-known and highly-valued reference book is unnecessary; there must be extremely few engineers in any branch who are not familiar with the earlier editions. The present edition contains important additional material as compared with the previous one; probably the most widely useful of the new features is a table of five-place logarithms of numbers from 1,000 up to 10,000, the numbers advancing by units up to 1,750, by twos up to 3,750, and by fives through the remainder of the table. The arrangement of the table is different from that which is usually employed, the numbers and logs. being disposed in two parallel columns, with the differences in a third parallel column. This will greatly facilitate the use of the table, as compared with the customary arrangement with the units of the numbers at the heads of nine columns. Another new feature is a series of tables for conversion between metric and English measurements. These are very conveniently arranged and include the logarithms of all numbers in each system that are equivalent to the units of the other system. The table of work equivalents is somewhat marred by the use of the terms "pound Fahrenheit" and "kilogram Centigrade," which are colloquial monstrosities intended to indicate the energy required to raise a pound of water one degree Fahrenheit or a kilogram of water one degree Centigrade. Until one digs out these definitions by dint of reasoning and familiarity with heat-energy relations, the statements: "1 foot-pound = .00128535 pound F.," "1 watt-hour = 3.4117 pounds F.," and so on, are intensely mystifying. The book has been very conscientiously revised, however, and the points that might be legitimately criticised are negligible in comparison with the immense value of the work.

OBITUARY.

FRANCIS HENRY WALL, lately the manager of the New York office of The Stanley Instrument Company, died recently of heart disease at his home in New York City. Mr. Wall was forty-five years old at the time of his death and had been connected with the electrical industry for twenty years. He had retired from active business a short time prior to his death.

WILLIAM PERKINS TYLER, president of The Tyler Tube & Pipe Company, died recently at his home in Washington, Pa. Mr. Tyler founded the business of his company twelve years ago and devoted all his conspicuously energetic efforts to building it up; he not only succeeded in this direction, but won the respect and regard of his business associates and the friendship of his company's employees. Mr. Tyler's interest in the business will pass undisturbed to his heirs, and his associates will continue the business on the lines laid down by him.

JAMES OSCAR NIXON, engineer and manager of the "silent-chain" department of the Link Belt Engineering Company, died recently of typhoid fever. Mr. Nixon, although only twenty-three years old at the time of his death, had earned an enviable reputation in engineering circles and was occupying a very responsible position. He was born in New Orleans, and graduated from Tulane University with the class of 1897. After taking his degree in mechanical engineering, he went into the work of sugar chemistry, and later became connected with the Link Belt Engineering Company. He was almost immediately assigned to the testing and mechanical development department of that company, in which line he manifested a high degree of genius. He leaves a young wife to whom he had been married less than a year.

PERSONAL.

MR CARL SCHWARTZ, formerly of Siemens & Halske, of Germany, has joined the engineering staff of the Chicago Edison Company.

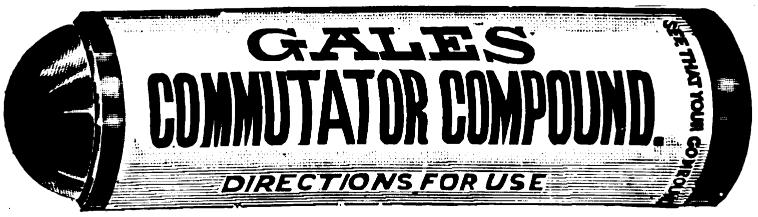
MR. W. S. CHASE recently resigned the treasurership of the Cleveland Machine Screw Company to accept the sales management for the National-Acme Manufacturing Company, of Cleveland.

MR. T. S. JACKSON, formerly connected with the Western Electric Company, Chicago, has accepted a position on the Chicago staff of the Fort Wayne Electric Works.

MR. FRANK WELZ has been appointed a member of the engineering staff of the Department of Electricity of the Louisiana Purchase Exposition to be held next year in St. Louis.

MR. THEODORE P. GILMAN has resigned his position as first deputy Controller for New York State to accept the presidency of The General Electric Inspection Company, of New York.

A COMMUTATOR NECESSITY.



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The Only Article that will Prevent Sparking.
Will keep the commutator in good condition and Prevent Cutting.
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It will put that high gloss on the Commutator you have so long sought for.

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MR. WILLIAM VULLMAN, for some time past superintendent of the Sturgeon Falls (Ont.) Electric Light & Power Company, has resigned that position to accept a similar one with the Vernon Electric Light Company, Vernon, B. C.

MR. HENRY C. MEYER, JR., has removed his office to 114 Liberty St., New York, where he will continue his practice as consulting mechanical engineer. Mr. Meyer makes a specialty of the design of steam power plants and mechanical equipments for buildings.

MR. R. M. BARWISE, who has been connected for some time with electrical interests in Philadelphia, has been appointed manager of the branch office in that city of The Buckeye Electric Company, of Cleveland, manufacturer of the well-known Buckeye incandescent lamp.

MR. MANNING K. EYRE has been advanced from the position of general sales manager of the Buckeye Electric Company, Cleveland, to the presidency of that company. Mr. Eyre has been identified with the incandescent lamp industry for ten years and is universally recognized as being one of the ablest men in the industry.

MR. A. B. GILBERT, who has been connected with the *Engineering News* for the past eleven years, has resigned the position of assistant business manager of that publication to accept the managership of the *Good Roads Magazine*, the *Teller, Central Station Directory*, and other publications of the E. L. Powers Company.

MR. A. KENNEDY ASHWORTH, formerly of the firm of D. Ashworth & Son, consulting steam engineers, and later for a number of years in charge of the engineering department of the Pittsburgh Gage & Supply Company, has been appointed assistant manager of the Underfeed Stoker Company, with headquarters in the Marquette Building, Chicago.

MR. LOUIS J. COSTA has severed his connection with Walker & Kepler, Philadelphia, to join the Philadelphia staff of The Jandus Electric Company which is under the management of E. L. Nash. The Eastern representation of the Buckeye Electric Company has been relinquished by Mr. Nash, and he and Mr. Costa will devote their entire energies to the interests of The Jandus Company.

MR. BERNHARD A. BEHREND has been made chief engineer of the Bullock Electric Manufacturing Company, Cincinnati. The compliment thus bestowed upon Mr. Behrend is conspicuously justified by the character of the engineering work he has done during the two years he has been with the Bullock Company. Mr. Behrend is regarded as one of the best designers of dynamo electric machinery of which the United States may boast at the present time. Mr. Behrend was born in Pomerania, Germany, May 9, 1875, and received his elementary education from a tutor at Verzin. In spite of a strong bent toward pure science, which was manifested at the Berlin Polytechnical Institute and University, he finally decided to follow the more practical side, and studied engineering under such eminent men as Helmholtz, Kundt, Slaby, Riedler, and a short time under Kapp. He was for some time assistant to C. E. L. Brown when Mr. Brown was with the Oerlikon Company at Zurich, Switzerland. Mr. Behrend left the employ of the Oerlikon Company in 1899, coming to the United States to recuperate his health, which had been undermined by overwork. In 1900 he was engaged by the Bullock Company as chief engineer of its alternating current department, from which he has now been promoted to the management of the company's entire engineering department.

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TRADE PUBLICATIONS.

CALENDAR. New England Electrical Works, Lisbon, N. H.—A cardboard and pad calendar bearing the trade mark of the New England Works executed in red on a black background.

PANEL BOARDS AND ACCESSORIES. Johnson & Morton, Utica, N. Y.—This is pamphlet No. 1008, containing illustrations, price-lists and dimensions of the well-known Johnson & Morton panel boards, cabinets, etc.

CALENDAR. The Standard Tool Company, Cleveland, Ohio.—A serviceable calendar consisting of a cardboard backing to which are affixed monthly calendar leaves. The cardboard contains practical tabulated information relating to the use of twist drills, reamers and taps.

PHOSPHOR-BRONZE. The Phosphor-Bronze Smelting Company, Philadelphia, Pa.—This is price list No. 21 of phosphor-bronze products which, as is well-known, are supplied in sheet, wire and rod shapes. The catalogue is of pocket size and the prices have all been revised as compared with those published in the previous price list.

DIRECT-CURRENT MOTORS. Crocker-Wheeler Company, Ampere, N. J.—Bulletin No. 29, in which is described a new line of enclosed and semi-enclosed multipolar direct-current motors. These machines embody the most modern features of engineering practice and are built in sizes ranging from 3 to 45 horse-power.

RAILWAY MOTORS. The Stanley Electric Manufacturing Company.—This is bulletin No. 130, containing a description and illustrations of the S. K. C. 401 railway motor, which is rated at 37½ horse-power; the rating being based on the usual shop test of 135 degrees rise in temperature at the expiration of one hour's run under full load.

CALENDAR. American Electrical Works, Phillipsdale, R. I.—A cardboard backing which bears a well-executed engraving of Sir Humphry Davy's portrait, together with the usual pad of monthly calendar leaves. On the rear of the card is printed a short biographical sketch of Davy.

POWER MOTORS. Western Electric Company.—Catalogue No. 3010 of the various stationary motors built by this company. The line of machines has been somewhat revised recently; some of the motors have been given more graceful curves than heretofore and modernized in small details which will be appreciated by the user. The catalogue is handsomely executed.

CALENDAR. John A. Roebling's Sons Company, Trenton, N. J.—An attractive card and pad calendar bearing a halftone illustration of the new East River Bridge, taken during the building of the suspension cables. The usual pad of monthly calendar leaves is attached to the lower part of the cardboard, and the dates are printed in very legible type of good size.

WORK WELL DONE. The British Westinghouse Electric & Manufacturing Company, London, England.—This is a somewhat unusual type of publication containing a description of the British Westinghouse works and a narrative of the preliminary work of locating and preparing the site for the establishment. The pamphlet contains also an interesting and quite lengthy sketch of Mr. George Westinghouse and short sketches of Messrs. Loud and Mitchell, works manager and superintendent respectively.

TRANSFORMER ECONOMY. General Electric Company.—This is publication No. 9115 and contains a most interesting comparison of General Electric transformer efficiencies in November, 1899, and October, 1902. The core losses of every size in the ordinary range of transformers built by this company have been reduced, and the copper losses of all except three sizes have also been reduced. The reduction in core losses ranges from 4½ per cent. to 29½ per cent., and the copper losses have been reduced from ½ of 1 per cent to 18½ per cent. The average temperature rise of the primary and secondary windings of the present transformers does not exceed 81 degrees Fahr. after carrying full load for eight hours.

CALENDAR CARDS.—Bullock Electric Manufacturing Company, Cincinnati, Ohio.—This is a set of twelve cards, each card containing on its face a calendar for one month and a portrait of some celebrated scientist, physicist or engineer, handsomely executed in colors. The faces of the cards are also ornamented by artistic designs executed in colors. On the back of each card is a short biographical sketch of the man whose portrait appears on the front. Among the celebrities included in the 1903 portraits are Joule, Tyndall, Huxley, Hertz and Bunsen. The list also includes an excellent portrait of Mr. Behrend, who has just been advanced to the position of chief engineer of the Bullock Company, as noted in another column.

SOLID TRAINS TO NORTHERN MICHIGAN.

The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.

All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

Cambridge Springs Winter Resort,
AND WHY.

The idea that because "a change" is needed it is necessary at this season to go to some much warmer climate, is not always correct. Such a course may sometimes be necessary, but in nervous troubles, disorder of the digestive functions, kidney complaints and many others, nothing is gained, and much is often lost by breathing an enervating atmosphere when vitality and vigor most are needed. Besides, one is seldom comfortable in such places because there are cold days there, with no facilities to meet them.

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BUSINESS NEWS.

THE BURT MANUFACTURING COMPANY, Akron, Ohio, recently shipped six Cross oil filters to Stockholm, Sweden, five to Buenos Ayres and six to Yokohama.

THE D. M. STEWARD MANUFACTURING COMPANY, manufacturer of lava insulators for electrical purposes, has removed its New York office from 107 Chambers Street to No. 8 Jay Street.

MICHIGAN ELECTRIC COMPANY, Detroit, Mich., on January 3 gave its second annual banquet to its employees at the Hotel Cadillac, Detroit. The banquet was attended by fifty employees, who were subsequently entertained by the company in a theatre party.

WESTINGHOUSE TRACTION BRAKE COMPANY is the name that has been substituted for the old name of The Standard Traction Brake Company, of New York. This company sells all of the brake equipments for street railway service that are manufactured by the Westinghouse Airbrake Company.

CHANGE OF NAME.—The Reynolds Electric Company, manufacturer of the well-known Reynolds flashers, has changed its name to The Reynolds Electric Flasher Manufacturing Company, and has also increased its capital stock to $15,000. The company's headquarters remain at 221 Fifth Avenue, Chicago.

THE PITTSBURGH GAGE & SUPPLY COMPANY, Pittsburg, Pa., is equipping the two 3000-h.p. Allis engines of the Pittsburgh Steel Company's Monessen plant with the White Star Continuous oiling system. Other contracts cover the equipping of three 400-h.p. engines for the Clairton (Pa.) Steel Company, and six 500-h.p. engines in the electric light and power plant of Union Depot, Pittsburg.

THE OTIS ELEVATOR COMPANY, New York, recently closed a rather unusual sort of contract for the equipment of a private residence with electric elevators. Five elevators will be installed in the single residence. These comprise a passenger elevator, a servants' elevator, a dumb waiter, a sidewalk elevator for ashes, etc., and an automobile elevator for raising and lowering motor carriages from the sub-basement to the street level, and the reverse.

THE DAYTON FAN & MOTOR COMPANY, Dayton, Ohio, has been licensed by The Diehl Manufacturing Company to manufacture fans embodying the features covered by the Diehl-Bennett patents. The injunction recently granted to the Diehl Company, restraining the Dayton Company from continuing the manufacture of these fans, will therefore have no effect upon the business of the Dayton Company so far as the consumer is concerned.

THE IRONTON ENGINE COMPANY of Ironton, Ohio, is the name of the new organization which has acquired the rights and business of the Allfree Engine Company. The new concern will hereafter build Allfree engines in all sizes, types and styles in new and modern shops which are now in process of construction.

GRATON & KNIGHT MANUFACTURING COMPANY, Worcester, Mass., feels such implicit confidence in the merits of its Royal Worcester and Heart brands of oak-tanned leather belting that reliable users of belting are invited to make their own tests of these brands, without expense to themselves if the belting should prove unsatisfactory.

THE ELECTRIC STORAGE BATTERY COMPANY has recently opened a new "Exide" battery depot in Rochester, N. Y. Although an "Exide" battery station is located in Buffalo, owing to the increasing use of electric vehicles in that portion of New York State, the opening of the Rochester office has been found necessary. It is located at the establishment of J. J. Mandery, 158 South Avenue.

THE FOSTORIA BULB & BOTTLE COMPANY, Fostoria, Ohio, desires to correct the impression that its plant has been destroyed by fire and that it is therefore not in a position to furnish inner globes for enclosed arc lamps. On the contrary, the production of inner globes by this company has greatly increased, and the company is in position to take the best possible care of all business entrusted to it. The factory of the Fostoria Glass Specialty Company was recently destroyed by fire, and this has undoubtedly given rise to the mistake referred to above.

THE CHRISTENSEN ENGINEERING COMPANY has opened an office in the Merchants' Loan & Trust Building, Chicago, for the sale of its electrical machinery. This office is under the management of Charles G. Burton, who made a great many warm friends in the electrical field during his connection with the Central Electric Company some years ago, and later with The Westinghouse Company. The Christensen Company has also opened a branch office at 906 Real Estate Trust Building, Philadelphia, under the management of H. A. Pike. This office will take care of the Eastern business of the company.

THE STANLEY ELECTRIC MANUFACTURING COMPANY has secured through its New York office a large contract from the New York Edison Company for alternators, rotary converters and transformers. This contract is notable not only on account of the amount involved but because of the sizes of some of the units. It includes four 2000-kw. rotary converters, twelve 800-kw. transformers, ten 1000-kw. rotary converters, with thirty 400-kw. transformers and three three-phase alternators of 3500-kw. capacity each. The Stanley Company at a meeting held January 10 passed a resolution increasing the capital stock of the company from $3,000,000 to $10,000,000.

INDUCTION MOTORS IN PAPER MILLS.—The Sturgeon Falls Pulp Company, of Ontario, Canada, is building a large paper mill which will be operated by induction motors throughout. Two Westinghouse Type "F" motors are to be used to drive the variable speed shaft of the paper machines, and two 75-h.p. Type "C" motors will drive the constant speed line shaft of the same machines. Another 75-h.p. Type "C" motor will operate other machinery in the mill. A 15-h.p. induction motor will be direct connected to a triplex pump; one of 10-h.p. will drive the wet machines; a 20-h.p. motor will drive the agitators for the clay-mixing tanks and a 30-h.p. machine will drive the conveyors. The order from the Westinghouse Company also includes a 560-kw. revolving-field alternator, designed for direct connection to a water-wheel, together with the exciter, switchboard and instruments. S. D. Warren & Company recently bought two Westinghouse induction motors of 100-horse-power each and one of 150 horse-power to be installed in their paper mill at Cumberland Mills, Maine. The two 100-h.p. machines will be used for driving blowers furnishing mechanical draft, and the 150-h.p. motor will drive paper-making machinery of various kinds.

JAMES McCREA & COMPANY, Chicago, manufacturers of steam specialties, report that the year just closed was the most prosperous one in the history of the firm, notwithstanding considerable expense entailed by placing four new specialties on the market during the past year. The sales of the Climax steam joint clamp for 1902 were more than double the sales for the previous year. A complete stock of these clamps are carried in the following cities by the dealers named. New York: George I. Roberts & Bros.; Boston: A. W. Chesterton & Co.; Philadelphia: Barrett & Plowman; Syracuse: Edward Joy; Pittsburg: Kelly & Jones Company; Cleveland: W. M. Pattison Supply Company; Detroit: Muzzy-Lyon Company; Indianapolis: Knight & Jillson Company; Cincinnati: Crane-Hawley Company; Louisville: Laib & Company; St. Louis: Western Iron & Supply Company; Milwaukee: Robert Rom Company; St. Paul: Western Supply Company; Kansas City: U. S. Water & Steam Supply Company; Omaha: U. S. Supply Company; Denver: Mine & Smelter Supply Company; Baltimore: John B. Adt; Atlanta: Cotton States Belting & Supply Company; Birmingham: Echols-Smith Hardware Company; New Orleans: The Fairbanks Company; San Francisco: The Plant Supply Company.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, of Chicago, Ill., recently gave a banquet at the Great Northern Hotel, Chicago, at which the following Stromberg-Carlson men were present: Alfred Stromberg, T. R. Finucane, C. W. Stiger, A. J. Rousseau, H. G. Webster, A. Hulbrich, Eugene L. Brown, F. L. Martin, William Bowen, F. L. Middleton, R. B. Tyler, E. C. Lewis, H. B. Hewitt, H. D. Eddy, L. R. Krum, C. E. Knickerbocker, A. S. Munsell, G. A. Muir, Paul D. Meyers, G. H. Pierce, B. B. Willis, H. L. DuPont, G. L. Burlingame, C. H. Hague. The banquet was given largely to enable the men to meet each other; also to furnish an opportunity of explaining to the salesmen the use of a new book of standard switchboard specifications, which the company recently got out. This has been pronounced by many prominent telephone men one of the most complete treatises on telephone switchboards that they have ever seen. Following the banquet and preceding the explanation of the book, Mr. Bowen, the company's Iowa representative, on behalf of the salesmen, presented Messrs C. W. Stiger and F. L. Middleton each with a handsome diamond scarf pin. General remarks were made by Messrs. Finucane, Stromberg, Middleton, Bowen, Brown, Rousseau, Stiger, Martin, Tyler, Meyers, Lewis, Smith, Munsell and Pierce.

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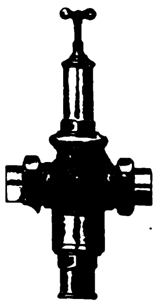

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American Electrician.

Vol. XV. New York, March, 1903. No. 3.

A SWISS COMBINED WATER-POWER AND GAS-ENGINE PLANT.

WATER-POWER STATION AT GOLDACH WITH AUXILIARY GAS-ENGINE PLANT AT ST. GALL.

One of the most important lighting and power plants in Switzerland using water power as a source of energy is that of St. Gall-Goldach. In the hydraulic power house two polyphase Oerlikon alternators are direct-connected to turbines which operate under a head of 417 feet. The current from these generators is transmitted from the Goldach station to St. Gall, a distance of slightly more than 3 miles. On account of the variable supply of the water power an auxiliary plant was installed at St. Gall, in which gas-engines are used for supplying the additional power required during heavy load periods. The gas-engine plant is so arranged that the engines are available for driving direct-current generators either simultaneously with the three-phase motors or independently. This electric power station at St. Gall is also equipped with a storage-battery plant, which acts as a regulator. A sub-station is also provided which contains motor-generator sets composed of polyphase motors and direct-current generators.

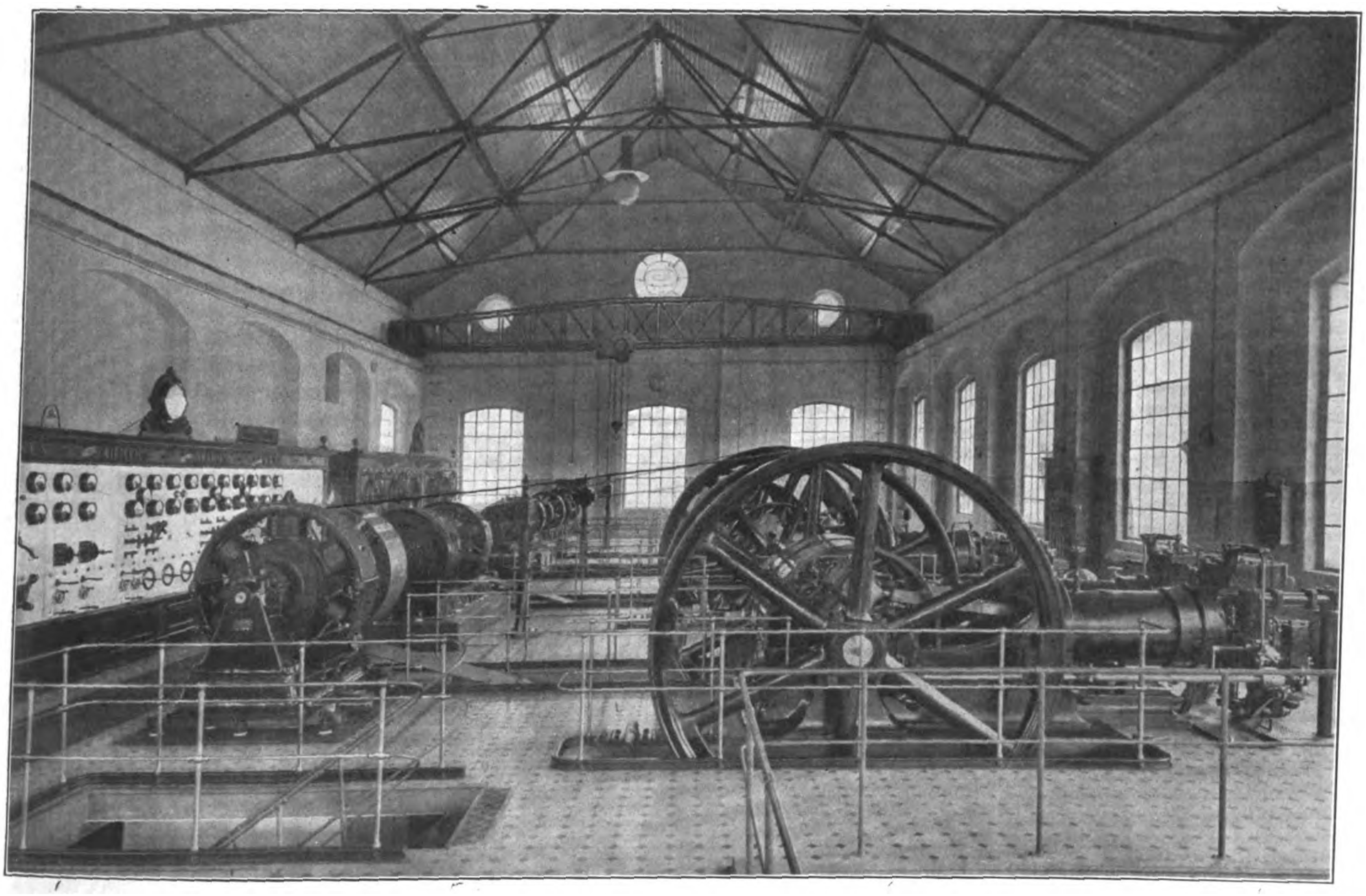


FIG. I.—VIEW IN THE GAS-ENGINE STATION AT ST. GALL.

THE HYDRAULIC STATION.

The river Goldach beginning near Oberegg in Appenzell Canton, flows into Lake Constance between Rorschach and Horn. On account of the irregularity of this stream, and the absence of reservoirs the power of the hydraulic station is excessively variable. The project was considered of building a reservoir at Untereggen, and the topographical situation was very favorable to the construction of a reservoir at this place, but a most expensive and solid construction would be required, costing about 350,000 francs, so that the construction of the reservoir has been temporarily abandoned, with the idea of taking it up again in the future. Measurements taken during a period of ten years showed that 400 horse-power was available for about 32 weeks in the year; 300 horse-power for about 37 weeks, and 200 horse-power for 45 weeks, while the output which could be depended upon for the entire 52 weeks of the year was only 100 horse-power. The beginning of the hydraulic installation was 9800 feet from the hydraulic station, and the stone for the construction was taken from the bed of the Goldach. Three gates were provided, two of which were arranged for the overflow. The entrance of the water into the canal begins at a height of 2000 feet above the sea level. The canal is 7300 feet long, the running slope being 1 in 1000. The section varies from 10 to 16 square feet. The conducting pipe supplying the water to the turbines is two feet in diameter, and consists of 13-ft. lengths of iron pipe, tarred inside and out. The pipe is placed underground, about 24 ins. below the surface of the earth. At the foot of the hill, the pressure pipe runs into a penstock 223 feet long, entering the Goldach central station on the west side. The turbines are located 1560 feet above the sea level, and the available fall at the power house is 340 feet.

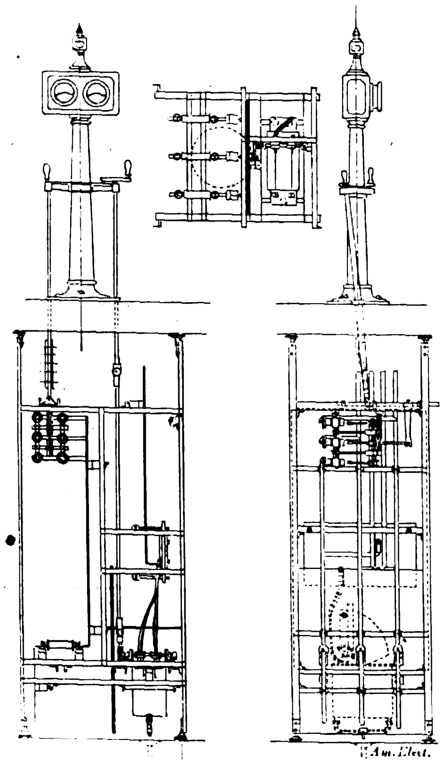


FIG. 2.—CONTROL GEAR.

The hydraulic-power plant is located on the left bank of the Goldach at a place called Lochmühle in the village of Untereggen. The basement of the building, the turbine room, and the penstock room are constructed of cement, the remainder being built of brick. The foundations and penstocks are arranged for three groups of machines. The first floor of the power-house is used for the turbine and generator room. Space is provided for one small and three large turbine-generator units, two of the large ones of which have already been installed. A small room is provided for a workshop and the telephone equipment is located in that. A 6-ton crane is provided in the power-house for handling the heavy machinery. The second floor is fitted up as living apartments for the engineer in charge.

The penstock entering the west side of the building is of wrought iron 5-16 in. thick, and the tube is 24 ins. in diameter. The two high-pressure turbines were constructed by Bell & Co., of Kriens and develop 200 horse-power at a speed of 530 r. p. m., and with a discharge of 5.6 cubic feet per second. The net efficiency of these turbines is 75 per cent at full load, and 72 per cent at half load. They are of the bucket type, and are provided with automatic regulators, as indicated in Fig. 4. All of the turbines are direct-connected to the generators by elastic insulating couplings. A small turbine of three horse-power capacity operating at 1650 revolutions per minute, drives a small dynamo for lighting the station.

The two alternators were built by the Oerlikon Works, and are rated at 200 kilowatts each. The normal speed is 530 r.p.m., at which speed they generate 3600 volts and supply current at a frequency of 53 cycles per second. The machines are of the inductor type, so that there is no moving wire on them. Each half of the armature core has 36 slots, in which are wound 18 coils of rectangular wire 142 mils by 165 mils in cross-section; each coil contains 38 turns. The wire in the field-magnet exciting coil is also of rectangular cross-section, the size being 216 mils by 236 mils; there are 550 turns in the magnet coil. Each exciter dynamo is driven directly from the shaft of the alternator and turbine set. The switchboard is of the usual panel type, and embodies no special features. The generator e. m. f. is raised by transformers to 10,000 volts for transmission.

THE ST. GALL MAIN STATION.

As just noted, there are two stations at St. Gall, one of which is known as the main station and the other as the sub-station, although the former figures as a sub-station when there is sufficient hydraulic-power to render unnecessary the use of the gas-engines installed there. The main station contains four Deutz gas-engines, having an aggregate capacity of 370 horse-power. These have been chosen of different sizes because the demand on the engine plant varies widely and the engines are supplied with gas from the municipal works, so that it is desirable to work them as near as possible at maximum efficiency. The gas-engines are belted to direct-current dynamos which are also arranged for coupling to three-phase motors, the practice being, of course, to drive the direct-current dynamos by means of the motors so long as the hydraulic plant at Goldach is equal to the demands of the system.

One of the smaller combined generating and converting sets consists of two direct-current dynamos, each of 40 kilowatts capacity, either or both of which may be coupled to a 60-h.p. three-phase motor. A 60-h.p. single-cylinder gas-engine is also arranged so that it can be used to drive one of this pair of dynamos by means of a clutch pulley, leaving the three-phase motor to drive the other one. The second group consists of two single-cylinder gas-engines of 30 horse-power each, belted to motor-generator sets consisting of two three-phase motors of 30 horse-power each and two direct-current dynamos of 20 kilowatts each. In this case the motors are, of course, capable of driving the dynamos at full capacity, whereas in the case of the set previously mentioned, the three-phase motor has only one-half the total ability of the dynamo part of the group. The third unit consists of a 66-kw. dynamo, which may be belt-driven by a 100-h.p. three-phase motor or by a 100-h.p. Deutz gas-engine. The fourth unit consists of a double-cylinder 150-h.p. gas-engine belt-connected to a 100-kw. direct-current dynamo, which may also be driven by means of a 150-h.p. three-phase motor.

All of the piping for the gas-engines is located in the basement of the power-house. For starting up the engines a hand pump is provided by means of which a charge is compressed in the cylinder so that the engine may be started up by an explosion. A check prevents the engine from starting under the influence of the compressed charge until the charge is fired, at which instant the engine is automatically released.

The 60-h.p. motor of group No. 1 is an eight-pole machine, and takes current through a transformer at 1560 volts; its speed is 725 r. p. m. The stator contains 72 slots, or three slots per pole per phase, in each of which there are 16 turns of wire. The rotor is 23½ inches in diameter, and has 160 slots. The two 40-kw. dynamos driven by this motor supply current at 275 volts. These machines have armatures 18½ inches in diameter and 12⅝ inches long. Each armature has 136 slots and is provided with a ring winding of 136 coils, each coil consisting of six turns of wire 118 mils by 142 mils in cross-section.

The second motor-generator set runs at 770 r. p. m. and delivers direct current at 130 volts. The dynamos of this set are used to take care of the unbalanced load on the three-wire lighting mains. The armatures of the direct-current dynamos in this set are 15½ inches in diameter and pro-

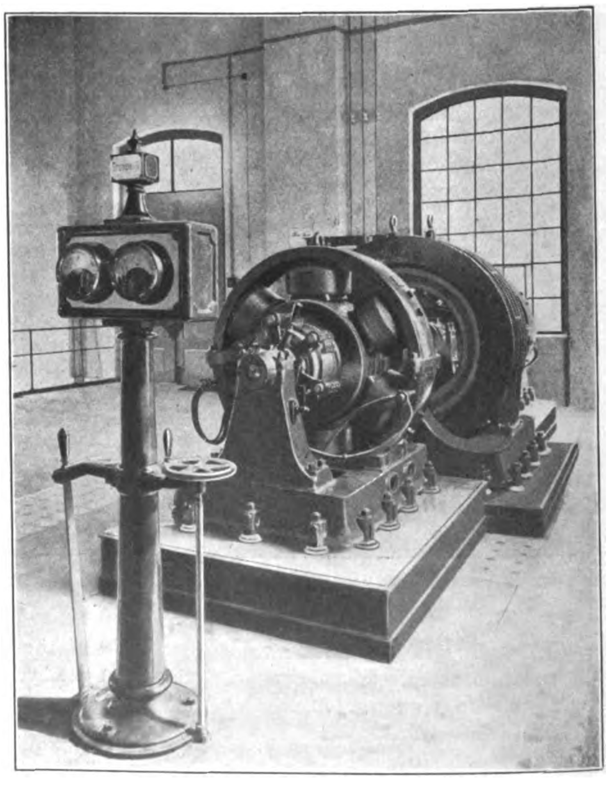
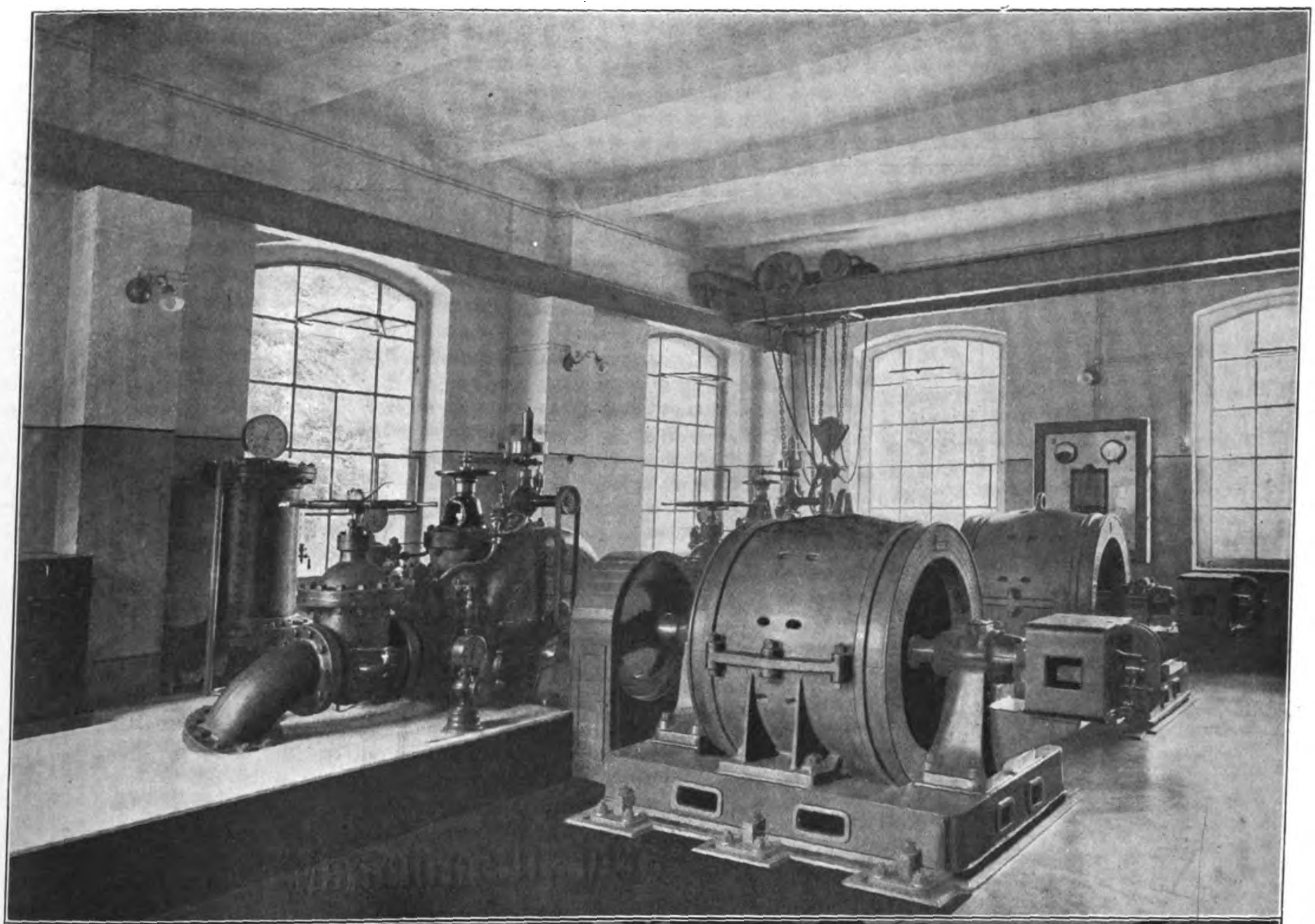


FIG. 3.—MOTOR-GENERATOR SET AND CONTROL PILLAR.



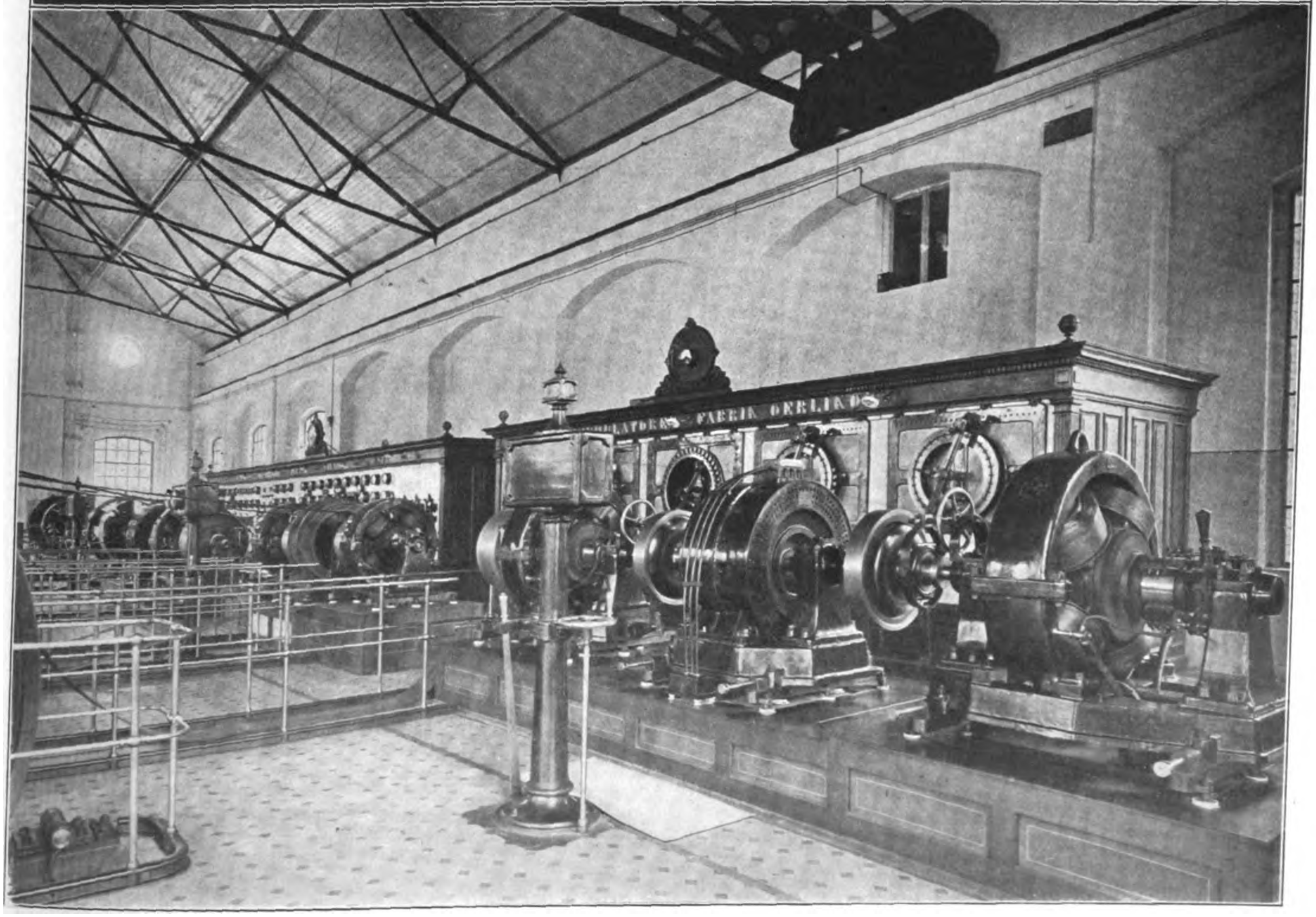

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FIG. 4.—WATER-POWER STATION AT GOLDACH.

FIG. 5.—VIEW OF MOTOR-GENERATOR SETS AT ST. GALL.

vided with 126 coils. The machines are four-pole. The 100-h.p. three-phase motor of the third group is a twelve-pole machine, and has a squirrel-cage rotor. The alternating e. m. f. supplied to it is 3300 volts, and the speed of the machine is 520 r. p. m. The bore of the stator is 35 7-16 inches in diameter, and the stator is provided with 144 slots, while the rotor has 180 slots. The direct-current dynamos of the fourth group deliver current at 275 volts.

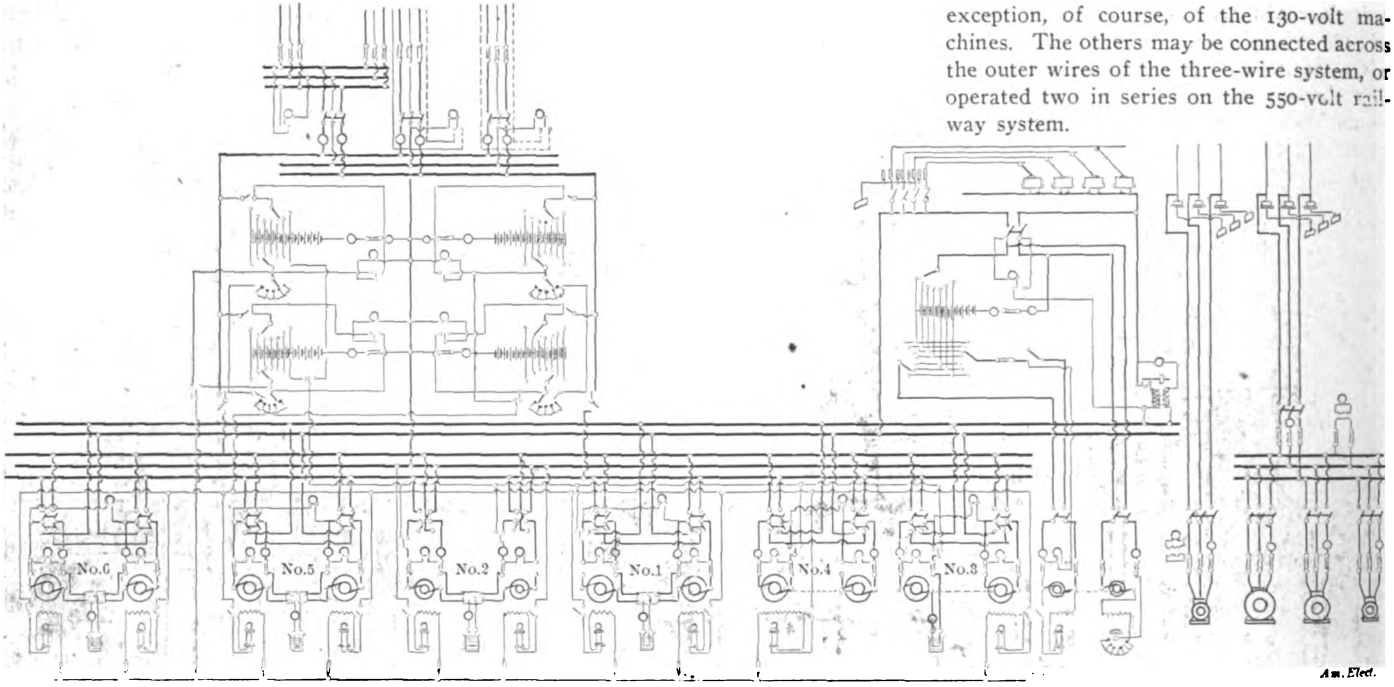


FIG. 6.—DIAGRAM OF SWITCHBOARD CONNECTIONS AT THE ST. GALL MAIN STATION.

The fifth and sixth motor-generator units are not arranged for driving by gas-engines. One of these consists of a 200-h.p. three-phase motor direct-connected to two 65-kw. direct-current generators, and the other a 250-h.p. three-phase motor driving two 80-kw. direct-current machines. Both of the three-phase motors of these groups are of the squirrel-cage type and operate at 3300 volts. The stator of the 200-h.p. machine has 168 slots with 12 conductors each, and the rotor has 210 slots, each containing 16 bare wires. The direct-current dynamos driven by these two machines also supply current at 275 volts. In fact, all of the dynamos are of this voltage, except the 20-kw. machines used to take care of the unbalancing. The alternating-current machines of all of the motor-generator sets are controlled from pilot pillars, the pillar for each set standing a few feet away from the three-phase motor of the set, as indicated in Figs. 5 and 3. The latter engraving shows group No. 5 of the motor-generators, which group does not appear in Fig. 5. As the engraving clearly shows, the pilot pillar carries at its head the necessary indicating instruments; on one side of the pillar is located the main switch handle, and on the other side the regulating hand-wheel. Fig. 2 is a diagram showing how the stems of these are carried down into the basement to the controlling apparatus. The switching arrangements of the direct-current machines are such that the machines may be utilized either on the lighting or the railway circuits, with the exception, of course, of the 130-volt machines. The others may be connected across the outer wires of the three-wire system, or operated two in series on the 550-volt railway system.

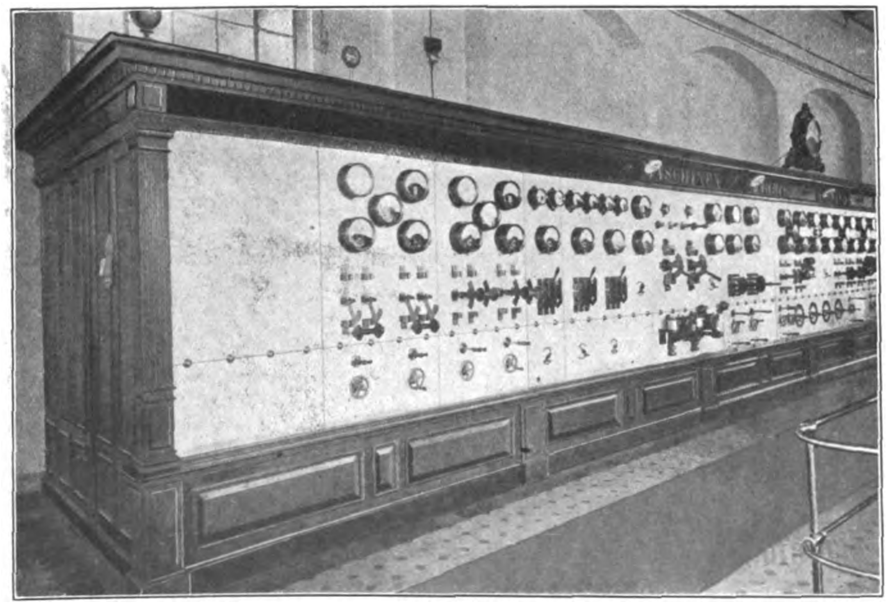


FIG. 7.—VIEW OF SWITCHBOARD.

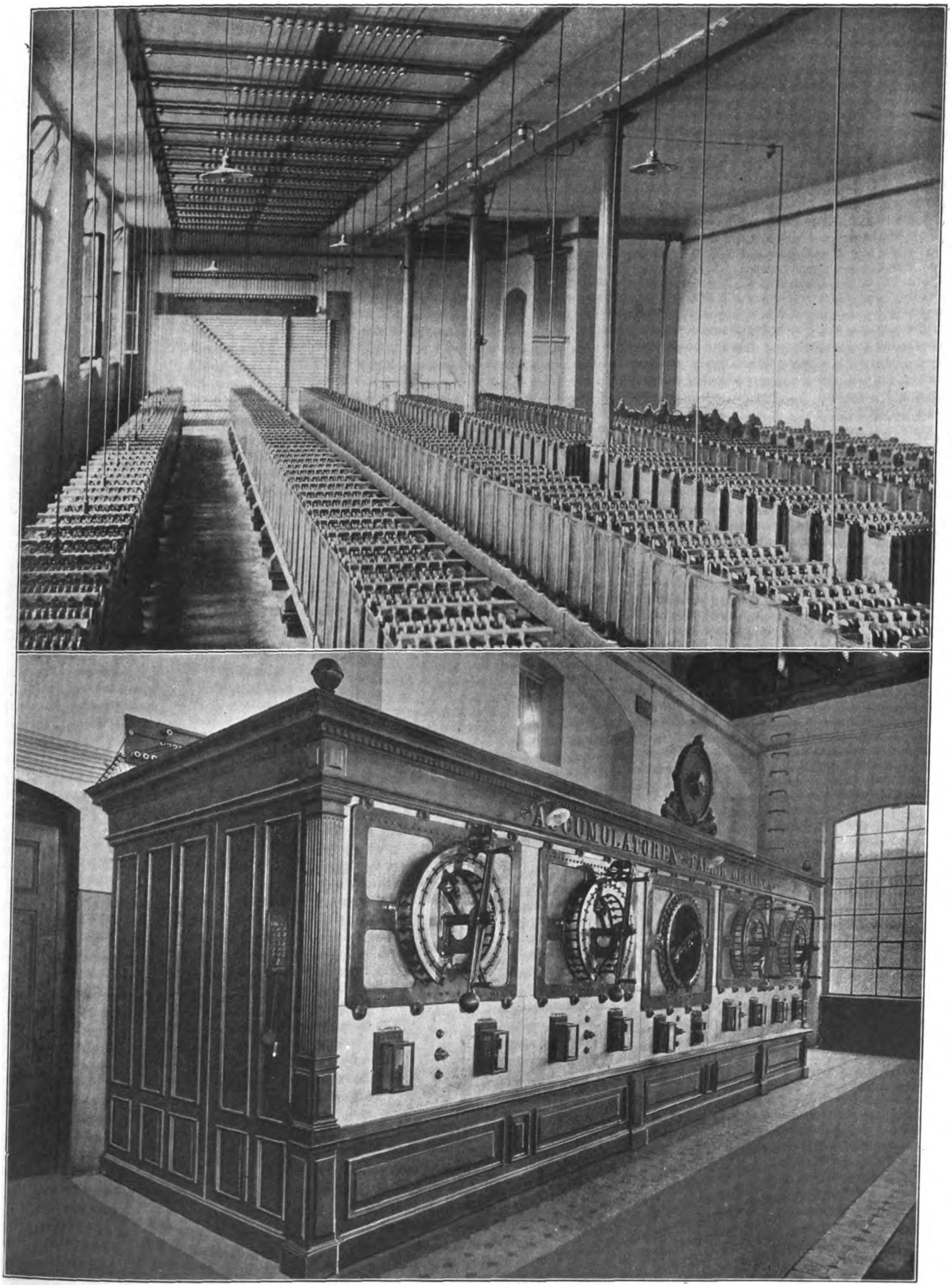
The storage-battery equipment at this station consists of 300 cells arranged in four groups of 75 cells each for use on the lighting system, and 300 other cells which are floated on the railway system in order to steady the demand on the generators and the voltage of the system. Fig. 6 is a diagram of the switchboard connections of this station, the part of the connections for the alternating-current apparatus being shown at the right of the diagram.

THE ST. GALL SUB-STATION.

The sub-station contains three motor-generator sets, each comprising a 250-h.p. Oerlikon three-phase motor direct-connected to a six-pole double-commutator direct-current dynamo. There are also step-down transformers which reduce the three-phase line current from 10,000 volts to 3400 volts, at which e. m. f. the three-phase motors in this station, as well as those in the main station, are supplied. The motors in the sub-station have wound rotors, with slip-rings, and run at 425 r. p. m. The stator of each machine has 168 slots, in each of which there are 14 rectangular conductors; the cross-section of these is 165 mils by 189 mils. The diameter of the rotor is 51 inches and it has 210 slots, in each of which there are 9 round conductors 134 mils in diameter.

The direct-current armatures are 33⅝ inches in diameter and 15 inches long. There are 129 coil slots .354 in. by 1.417 ins., and 129 coils to each commutator, the winding being a simple two-path wave. Figs. 10 and 11 illustrate the construction of these machines and also show the principal dimensions.

The basement is divided into three parts,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FIGS. 8 AND 9.—THE STORAGE BATTERY ROOM AND STORAGE BATTERY SWITCHBOARD AT THE ST. GALL STATION.

one containing the high-tension connection cut-outs and 10,000-volt bus-bars, as well as the high-potential cut-outs for the transformers. The middle section contains three transformers, two of which have a capacity of 200 kilowatts each, and the other 100 kilowatts. The third section contains the 3400-volt bus-bars, cut-outs and other secondary control apparatus.

The municipal high-tension line consists of three insulated wires 177 mils in diameter mounted on single wooden poles. The conductors are carried on an overhead line to the St. Gall-Rorschach Railway, where the lines run into a tower constructed of wood and containing lightning arresters, switches, etc. From there the line runs under the railroad track in a high-potential triple-conductor cable, which is laid at a depth of two feet below the surface and on a solid bed 7⅞ inches thick.

The high-potential line between the Goldach hydraulic power station and St. Gall consists of three bare copper wires 216 mils in diameter. This transmission line is carried on a line of wooden poles which are located 105 feet apart. The high-tension line enters the municipal electric station, entering through a tower which is supplied with lightning arresters and high-potential switches. The total length of the line is a trifle over three miles. The main station at St. Gall is supplied with current from the sub-station at 3400 volts over a three-conductor cable, the distance being only 1250 feet.

The lighting and stationary motor circuits of the distribution system are all three-wire, with a service potential of 120 plus 120 volts. On the municipal direct-current lighting circuit there are 2500 lamps installed of 16 candle-power each, and a large number of direct-current motors are used on the St. Gall commercial power circuit, ranging from ¼ horse-power upward. The municipal arc lighting service is supplied by using two lamps in series, each of 1400 candle-power nominal. The private incandescent lighting includes 5500 incandescent lamps of from 10 to 50 candle-power each, as well as a large number of arc lamps. The charge for electric current for lighting is 7 cents per kilowatt-hour, and at the end of the year a rebate is allowed to subscribers according to the consumption; the rebate on bills of from 4000 to 10,000 kilowatt-hours is 3 per cent; 10,000 to 20,000 kilowatt-hours, 5 per cent; 30,000 to 50,000 kilowatt-hours, 10 per cent, and above 70,000 kilowatt-hours, 20 per cent. The rates for current for small motors for 10 hours' use are 250 francs per annum for motors of ½ horse-power; 420 francs for motors of 1 horse-power and 1050 francs for motors of 3 horse-power.

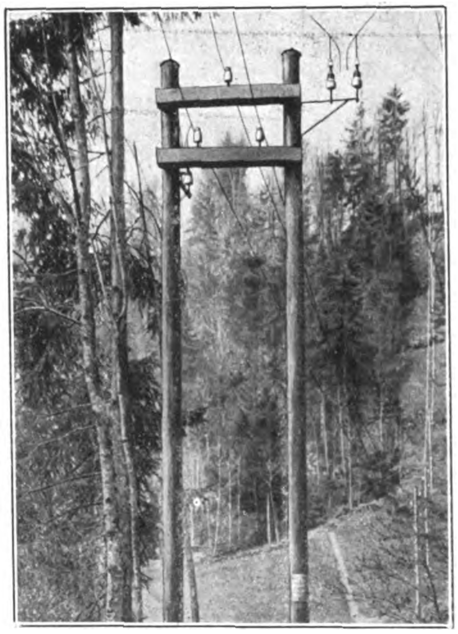
FIG. 12.—TRANSMISSION LINE.

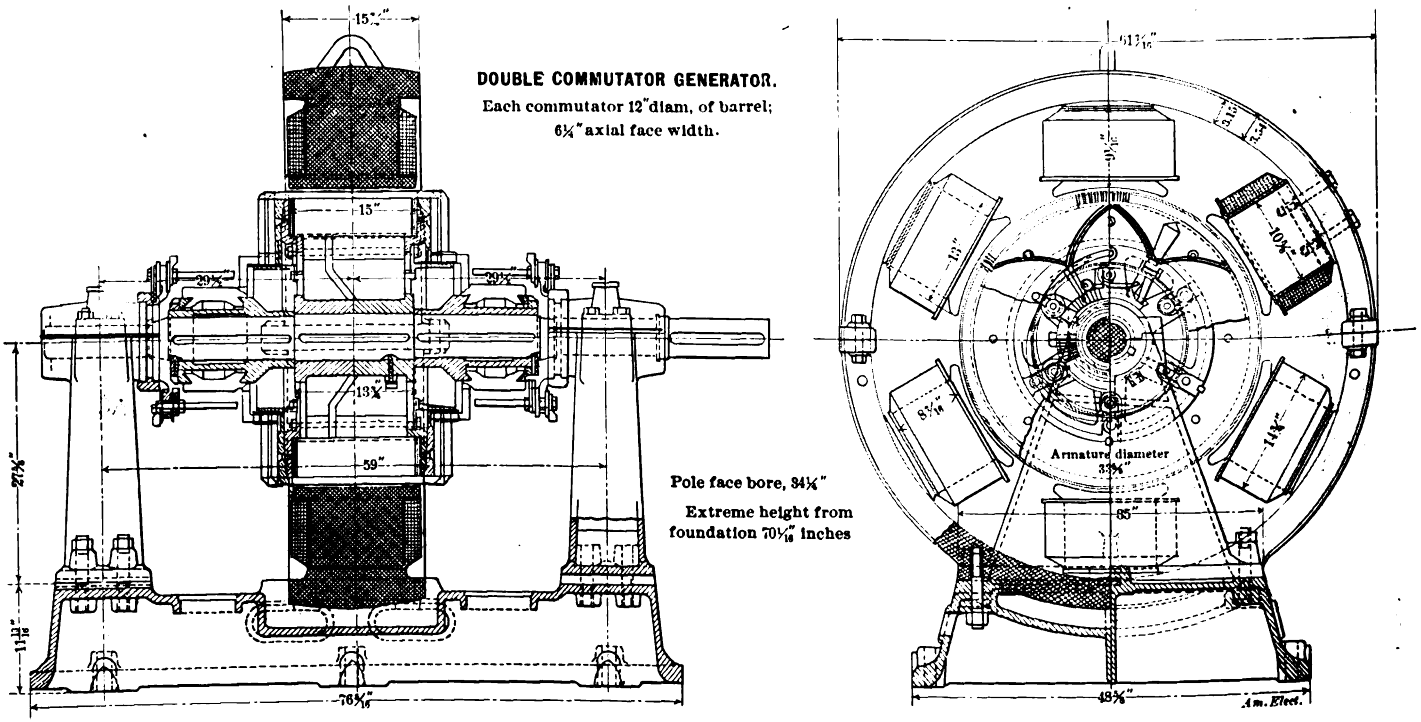

FIG. 10.—AXIAL AND SIDE SECTIONAL VIEWS OF DOUBLE-COMMUTATOR GENERATOR—FIG. 11.

The current for the railway lines of St. Gall is supplied from the power house at Goldach, and the auxiliary main station and sub-station at St. Gall. The railway feeder circuits are supplied with current at 500 volts, 50 volts being the drop on the line. The rolling stock consists of 30 motor cars, four trailers, one snow-plow and two freight cars. The motor cars are equipped with electric brakes.

We are indebted to Mr. F. C. Perkins for the illustrative material and most of the engineering data presented in this article.

* * *

LIQUID FUEL.

BY H. F. SCHMIDT.

During the last three years there has been a revival of and a greatly increased interest in the use of oil for fuel, caused to a considerable extent by the discovery of a large number of wells throughout the world, producing oil that is particularly suitable for use as fuel. There are many general advantages that have turned the attention of engineers to the use of oil for fuel. It undoubtedly furnishes the most complete solution of mechanical firing and reduces the fire-room force to a minimum, two men being able to care for 2500 horse-power with comparative ease. Though oil is more expensive than its equivalent in coal, there are no ashes to be removed, with an expense for cartage, and there is no loss of fuel by cleaning out fires and by banking the fires over night. In addition the fires can easily and almost instantly be controlled to meet any demand for steam, and when desired can be reduced or even entirely extinguished just as quickly, whereas with coal, it takes time for the fires to be increased, and when coal has once been put in the furnace it must be allowed to burn out, generally causing a loss of steam through the safety valve.

This ability to control the supply of heat according to the demand, commends oil fuel for use in electric lighting and railway power stations where there is liable to be a sudden demand for power, as in summer when a storm comes up suddenly, and also for the heavy morning and evening demand. Furthermore, the furnace doors are never opened, and fire tools are dispensed with, both of which add greatly to the life of a boiler and the brickwork. Moreover, there is no coal dust in the fire room and the adjacent engine room, as well as an absence of smoke without. The result of observation shows that the average amount of smoke made by furnaces fired by oil when properly managed is about 0.4 by Ringelman's chart, which amount is beyond all criticism as a "smoke nuisance." Again, volume for volume, the same calorific power can in the case of oil be stored in about one-half the space occupied by the equivalent in coal.

On the other hand, crude oil gives off vapors which, when mixed with certain proportions of air are explosive, and for this reason it is prohibited by the fire and insurance ordinances, and in some cases by the Board of Health because of the noxious odor. When permitted at all, the fire ordinances make it compulsory to store the oil below ground, making it necessary to pump the oil to the burners. If the fire ordinances make it necessary to use fuel oil, the cost is considerably increased, though this objection is now partially obviated as a cheap method of partial distillation has been devised which almost totally removes the sulphur and lighter oils, and leaves the calorific power almost unchanged. It may also be argued with reasonable assurance that if oil were to be very widely used for fuel, the price would be greatly increased, as the supply of oil is uncertain. Further, it is necessary to have a storage for air, or else an auxiliary boiler to supply steam to the burners of the main boilers till steam is raised in them.

It is well known, too, that oil has a "habit" of leaking past valves which it is impossible to stop and which may result in dangerous accidents. And again, it is usual to provide a connection to the boiler by means of which the oil pipes may be blown out with steam, making it possible that through carelessness oil is liable to get into the boiler and cause an accident similar to that which occurred in California a few years ago. Finally, as most burners of the spraying class make a loud roaring noise, they might bring forth objections from the Board of Health if used within city limits.

The failure of trials with oil fuel that were made several years ago were principally due to the fact that the experimenters tried to burn the oil in the same manner that they burned coal; in other cases failure was caused by the reverse attempt of trying to turn the oil into a gas and consume it in that form. Both these methods resulted in the deposit of large masses of solid carbon which soon clogged up the apparatus and were very difficult to remove. It is impossible to completely gasify the oil, and experiment, as well as sound reasoning, show that it should be thoroughly atomized instead. The efficient, economical and rapid burning of oil depends upon the degree to which it has been atomized and the efficiency of any burner depends upon its ability to atomize the oil and deliver a mixture of air, hydrocarbons and infinitely minute particles of carbon, so that complete combustion will take place. Heating both the air and the oil help to accomplish this result, and it has been found that it is absolutely necessary that both the air and the oil should be first heated if any degree of success is to be obtained and forcing is desired.

It was not until within the last three years that it was possible to burn sufficient oil under a boiler to make the evaporation equal the highest rate obtainable with coal, but with preheating of the oil and air it has been conclusively proven that the limits of forcing with coal can be far exceeded, if it should be desirable.

The proper temperature to which the oil should be raised before entering the burners has not yet been definitely determined, but as far as observations have been made it would appear to be not far from 145 to 155 degrees Fahr. A simple and convenient method of heating the oil is to pass it through a coil surrounded by steam from the boiler, but one of the chief requirements for the uniform operation of a burner is to keep the temperature of the oil as constant as possible, and the method mentioned does not accomplish this result, because when the supply of oil to the burner is changed, the temperature is changed, causing a change in the fluidity, and again a change in the supply until equilibrium obtains; in the meantime the apparatus requires the entire attention of the attendant. The oil should not be heated too much, for it will then deposit carbon, which will clog up the piping and burners. A simple, cheap and satisfactory method of heating the oil has not yet been devised, and is much needed. Another requirement is that the pressure of the oil must be kept constant, but this is somewhat simpler than maintaining the temperature constant.

If uniformity of operation is desired, the pressure and temperature of the air supply must also be kept constant. The former can be approximately accomplished by means of constant pressure reducing valves and rotary blowers, and if air pumps of the reciprocating type are employed, by the use of large receivers between the compressors and burners. The air can be economically and conveniently heated, in the case of water-tube boilers, by placing a coil of pipe in the ash-pit, and thus utilizing the downward radiation from the flame.

The problem of keeping the temperature of the air constant is still more difficult than that of maintaining the temperature of the oil constant, as there are more factors which cause its variation. In this connection it will be well to state that experience has shown that the size and arrangement of the piping to the burners play a very important part, and that the size should be such that the supply to all the burners is the same. Also, in order to avoid the clogging of the oil pipes and burners, the oil should be thoroughly filtered, a pair of filters being provided in order that the supply of oil will not be interfered with when one of them needs cleaning.

The brick work of the furnace should be so placed that the flame does not impinge on it, for if it does, a solid cake of carbon will be deposited which is difficult to remove, and which represents a loss by imperfect combustion, though this loss is trifling. The average temperature in the center of the furnace has been found to be about 2000 degrees Fahr., and in the stack the temperature observed was also very high, showing that a material increase in the heating surface might prove advantageous. Experience has also shown that a reduction in the calorimetric area is of decided advantage, and that the volume and form of the furnace decide much. These points undoubtedly show that the design of the boiler may have much to do with the degree of success attained in the use of liquid fuel.

It has also been found that for the complete combustion of the fuel it is necessary that the attendant shall have a means of observing the appearance of the discharge at the top of the stack, as the only criterion of the process of combustion by which the operation can be guided is the smoke issuing from the chimney. After some experience has been obtained, it is also possible to judge combustion quite accurately by the sound of the burners and the color of the flame. In regard to the quality of the oil used, it has been determined that the calorific power of all fuel oils is practically the same, and that it is better to use an oil that has had the sulphur removed, as this does not reduce the calorific power, and where steam is used for atomizing will prevent the possibility of the formation of sulphuric acid which might attack the metal of the boiler. So far, however, it has been proven beyond all doubt that the use of oil fuel is not at all injurious to the boiler, notwithstanding this has often been urged against its use.

As to the best means to use for atomizing, it is quite certain that air is superior to steam, and it may be said that contrary to popular belief, steam does not increase the furnace temperature, but on the contrary tends to lower it. The steam is at first disassociated by the heat of combustion of the oil, reducing the available heat by just so much, and then the reuniting of the oxygen and hydrogen of the steam in the cooler part of the furnace producing the same number of heat units per unit of weight that was required to disassociate it. But not all of the oxygen and hydrogen reunites again, and this is where the loss of heat occurs when steam is used for atomizing. Furthermore, the steam only displaces the air required for the combustion of the oil, and acts like a diluent, hindering the combination of the fuel and oxygen of the air.

The question as to which type of burner is the best has not yet been fully determined, but a few points have been settled, though the final selection of the best type will require considerably more experimenting. That the air-and-steam type is not advantageous has been quite thoroughly demonstrated by experience, which has shown that it requires more attention and is more difficult to regulate than either the steam or air type. It also has the disadvantage of using more steam than either of the other types. The steam-air type uses about 7.32 per cent of the total weight of steam generated, as compared with a rough average of 4.79 per cent for the steam, and 3.18 per cent for the air type. These figures, however, were taken from a series of tests varying in some cases very widely and therefore might not be strictly true if the conditions had been the same in each case.

When steam is used for atomizing it should be superheated, and it is also, to some extent at least, more economical to use it at high pressures. Boilers can not be forced to the same extent with steam atomizing as with air for the atomizing medium. Experiments in California conducted with several different types of burners showed that the weight of air used for atomizing the oil was about the same as the weight of water evaporated. That is, one pound of air was required for each pound of water evaporated, and a plant that was calculated on this basis has given complete satisfaction.

Summing up the foregoing, it may be said that in general oil is more expensive than coal of the same calorific power, excepting, perhaps in California, the Western and Southwestern States. This is at present due to the excessive transportation rates, but these would undoubtedly be reduced as soon as the demand for oil increased to any great extent. This difference in cost is, however, balanced, if not wholly, in part at least, by the absence of ashes and the consequent carting, and the reduction of the fire-room force to only one-eighth or even one-tenth of the staff required when coal is used. Besides this, the saving in the waste of fuel through the grate bars and the loss by banking fires, as well as the ability to meet sudden demands for power are items of considerable weight. The careful study of a number of tests shows that the percentage of the total available heat energy resident in the fuel that is absorbed by the boiler in the case of oil fuel is the same as with coal, the conditions of forcing, etc., being the same in both cases. Within city limits the absence of smoke is of great importance, though this can also be secured by the use of mechanical stokers and forced draft in a plant using coal. The oil installation, however, requires pumps for the oil, an air compressor, and an air storage tank, which take up room, and if the pumps are not of the best and do not receive the best care they are liable to get out of order quickly. On the other hand, in the coal plant there are grates that must be renewed, and the brick work does not last so long but must be replaced at frequent intervals.

From what has been said, it is evident that no definite conclusion can be arrived at without making a special study of the conditions under which a plant is to operate, and carrying out extensive experiments to determine the type of apparatus best fitted for the special class of work to be performed. Each particular plant should be worked out as a problem of itself. It is not advisable to attempt to install oil-burning appliances under boilers already erected, or even in a new plant without first consulting experts on the subject, as the efficiency and successfulness of the installation will depend largely upon the type and arrangement of the auxiliary machinery employed, and it is highly probable that a specially constructed boiler would be desirable.

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TELEPHONE ENGINEERING.

Treatment of Poles.

BY F. L. DOMMERQUE.

Several processes of treating poles with preservatives have been developed, but those in general use are the sulphate of copper process, which is used most in Central Europe, and the creosoting process, used in this country. The method followed by the German Post-Office Bureau will serve as a typical example of the sulphate of copper process. The place where the impregnating takes place is usually selected close to the forest where the poles are cut. One of the principal requirements for the proper location of such a place is that pure water can easily be obtained, free of chalk or iron, for the preparation of the sulphate of copper solution. The poles are delivered at the place with the bark still on, the branches trimmed close to the trunk, and the ends cut off at right angles to the axis of the pole. The poles are brought to the place directly after they are cut; if they cannot be treated within ten days after being cut, they are kept under water.

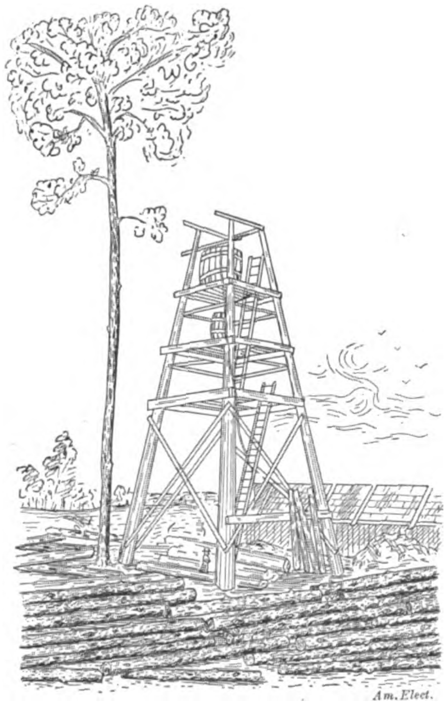

FIG. 1.—SCAFFOLD.

The treatment begins by resting the butt ends of the poles upon a scaffold, while the tops lie on the ground. The solution is injected either by hydrostatic or steam pressure. The solution consists of 1½ parts sulphate of copper to 100 parts of water, by weight, and is prepared in a tank located on the ground or partly sunk into the ground. When hydrostatic pressure is used, a scaffold is erected with several platforms, according to the sizes of poles that are to be treated, as shown in Fig. 1. Upon each platform a tank is provided into which the solution from the mixing tank is pumped. From the pressure tank a pipe leads vertically down to the level of the butts of the poles and there turns horizontally and passes along or rather in between the butts of the poles that are arranged on both sides of this pipe on the scaffold, this stage being only a few feet above the ground so as to give the solution sufficient pressure due to its fall to penetrate the whole length of the poles. Fig. 2 shows this stage and also the horizontal part of the feeding pipe provided in front of each pole, with a nozzle to which a rubber hose can be attached, the other end of the hose to fit a wooden plug *K*, Fig. 3, driven into a hole *P* in a square piece of two-inch plank *ST*; this plank is held to the butt of the pole by hooks *b* and *b'*, the two points *c* and *c'* being driven into the pole and the two other ends being provided with a screw thread and nuts so that the plank may be drawn against the butt as tightly as needed. Between the plank and the butt a chamber which serves as a receptacle for the solution is formed by laying hemp rope (*i* and *i'* in Fig. 3) around the edge of the butt. In Fig. 2 is shown a trough under the butts, intended to catch any drips and return them to the mixing tank. Of course, all pipes must be of lead or copper to withstand the chemical action of the solution.

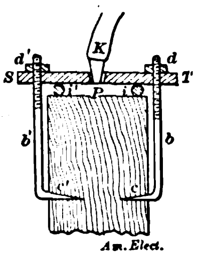

FIG. 3.

Where steam pressure is used the solution is transferred from the mixing tank into a second tank, from which it is pressed into the chambers at the butt ends of the poles by a steam pump under a pressure of 15 to 20 pounds. In France a similar process is used, with the difference that in the application of hydrostatic pressure the tank on top of the scaffold contains a basket filled with crystals of sulphate of copper through which the water is pumped, whereby the mixing tank is made superfluous.

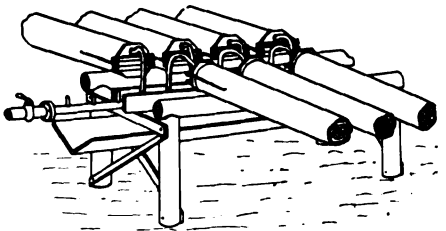

FIG. 2.—ARRANGEMENT OF POLES.

Probably the most effective substances for the preservation of timber are obtained from the by-products of the manufacture of gas, principally the dead oil of coal tar ordinarily called creosote. The creosoting process is used to some extent in the United States, and is described fully in a little book on creosoted timber, issued by the Norfolk Creosoting Company, and from which we quote by kind permission of the company.

The preservation of timber by the dead oil of coal tar process, as carried on by all well-equipped creosoting plants, consists of two distinct operations: the preparation of the wood and its impregnation with the preservative. The preparation of the wood necessary for the proper reception of the preserving substances is the removal of all those portions of the tissues which are subject to fermentive action. This consists of the extraction of the liquids and semi-liquids occupying the interfibrous spaces and constituting the very immature portions of the wood, without softening the cement binding of the fibrilla, or bundles of cellulose tissue, forming the solid or fully mature part. Upon the successful accomplishment of this entirely depends the value of artificially preserved wood for structural purposes. If this step of the operation is conducted at too low a temperature, or for too short a time, the sap or liquid part nearest the surface will only be extracted, the consequence of which will be an insufficient space for receiving the preservative. If, on the other hand, the operation is carried on at too high a temperature, or for too long a time, the resinous portion of the bundle of fibrilla will be softened and the wood lose its elasticity in just the proportion that the coherence of the fibrilla is lessened. The temperature should never be less than 100 degrees C., or greater than 130 degrees C.

Of the two possible methods for the removal of the undesirable portions of the timber, exposure to currents of dry air, and steaming under pressure with an after-drying in a vacuum, the latter is now the universal practice. While the first-named plan may seem the more rational, and the one least likely to modify injuriously the physical structure, such is not the case. Under proper manipulation, a more thorough desiccation, without harmful change of the organic structure, can be accomplished in twelve hours less by the latter process than is ever possible with air drying, which, under the most favorable circumstances is a long-drawn-out operation and cannot do more than extract the water from that portion of the sap which has not yet reached the semi-solid stage, thus leaving in the tissues of the wood a very considerable amount of resinous matter which occupies space that should be ready to receive the creosote oil. The consequence of this is a failure of the oil to reach many of the interfibrous passages, which are either left empty or are filled with the gelatinous part of the half-matured growth cells in which are to be found the conditions that make putrefaction possible.

In order to remove the sap from the wood, it is first necessary to vaporize it and then bring about such external circumstances which shall allow outflow of all gaseous matter from the interior of the wood. In order to vaporize the sap it is necessary to break down the walls of the cells containing the liquid and semi-liquid substances. This is readily accomplished through the agency of heat applied through the medium of a moist steam bath, at such a pressure as to keep the temperature of the wood and its surrounding atmosphere somewhat above the boiling point of the sap. The maintenance of this condition for a few hours is found to be quite sufficient to break down the sap-cell tissue and to vaporize all those constituents that it is desirable to withdraw. This point having been reached, the steam bath is discontinued; and the temperature being maintained at, or slightly above, the vaporizing point of the sap, the pressure of the atmosphere surrounding the wood within the chamber is reduced below that of the interior of the wood. The result of this condition is an outflow of vapor and air, continuing until equilibrium is restored. This equilibrium is prevented by the use of an exhaust pump until the absence of aqueous vapor in the discharge from the pump indicates the completion of the operation. At this stage the wood tissue is in a state very like that of a sponge cleared of hot water; every pore is gaping open and ready to receive the oil.

In the practice of the Norfolk Creosoting Company the more carefully dried lumber is steamed and subjected to the action of the heated "vacuum" in order that there may be had that thorough and uniform penetration of the preserving liquid that is essential to the highest efficiency of the product. The timber having been thus prepared the creosote oil is admitted to the chamber, which is still kept under the influence of the vacuum pump, at a temperature somewhat above the boiling point of the sap, at the pressure then existing in the chamber. As the hot oil envelops the wood and enters the interfibrous spaces, the aqueous vapor yet remaining in the wood, by reason of its less specific gravity, rises to the top of the containing chamber, and is withdrawn by the pump. By the time that the chamber is entirely filled with oil, all the remaining moisture has escaped. The exhaust pump is stopped and, in order to facilitate the absorption of the oil by the wood, a pressure pump is set to work supplying oil to the chamber at such pressure as may be desired. This operation is continued until the requisite amount of oil has been put in the timber. The chamber is then opened and the timber withdrawn. The apparatus is then ready for further use. The book referred to contains also a set of specifications for creosoted timber, which convey further information on the subject, and it is cordially commended to the attention of those interested in the construction and maintenance of pole lines.

Before leaving this subject the writer will mention some means that are employed frequently to treat the poles just above and below the surface of the ground without going to the expense of impregnation. The rain sinks into the ground to a depth of from 13 to 18 inches, and over this region the poles are first attacked; the action of the weather upon the pole is illustrated in the left-hand sketch of Fig. 4. To keep the rain from coming in contact, or rather from remaining in contact, with the pole at that point, a simple means is suggested, namely, to build up the refilling around the pole from 18 to 24 inches above the level of the ground wherever possible; this will make the rain-water run away from the pole and will also present a greater area to perforate. Many other means of prevention have been suggested and tried with success. Tar oil has been poured around the pole into a recess formed by removing the ground about three inches all around the pole for some inches into the ground. A gallon will about fill the hole, which is then covered up with the soil. Others again have made a deeper recess around the pole, from two to three feet deep, and filled same with rock salt taken from the beach.

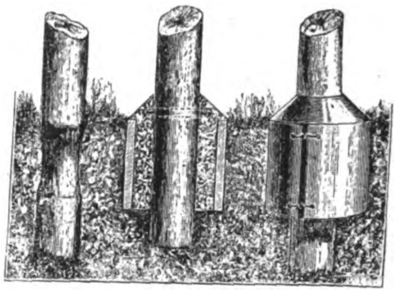
FIG. 4.—POLE PROTECTION.

Another contrivance used in France is called a *"garde-bois."* A split terra cotta cylinder is set about 18 inches into the ground, and the space left between the inner wall of the cylinder and the pole is filled with concrete. On top of the cylinder a layer or ring of sized oakum is placed and covered with cement to a cone-shaped roof, so that the rain may easily run off. The central and right-hand sketches in Fig. 4 illustrate this *garde-bois*. It is claimed that this cylinder prolongs the life of the pole five-fold.

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Belt Running.—A very common question and one often discussed is whether a belt will run to the high side of a pulley or not. For instance, if two shafts are out of line, not parallel with each other, one side of the pulley must be farther from the opposite pulley than the other side of that pulley, therefore one edge of the belt is tighter than the opposite edge. Some men seem to think the belt would run to the slack side and off, but it will not. The belt runs toward the highest side for the very same reason that a belt will stay on a crowning pulley. The tight edge becomes, from being tight, the leading side of the belt, and the rest of the belt follows simply. If a rider wants to direct a bicycle in another direction he turns the forward wheel in the direction he wishes to go and the rest of the machine follows. The direction of movement of a shaft out of line is indicated by the position of the shaft to the belt, and the belt simply follows in the direction indicated by the pulley: toward the tight side.

AMERICAN METER PRACTICE.

Torque and Friction.

BY LYMAN C. REED.

The word "torque" is used to express the force with which a rotating body tends to revolve and is usually expressed in foot-pounds. "Counter torque" is a force acting in opposition to torque; thus, the friction of a moving body may be expressed as counter torque, the overcoming of which consumes a certain proportion of the torque of the rotating body. In a meter the torque is a minute fraction of a foot-pound and the counter torque or friction is a smaller quantity still.

If a half dozen different makes of recording wattmeters are set up and tested when new, a very slight difference may be noticed in their readings on full and medium loads, but very decided differences are recorded on light loads from 5 per cent and under of the full-load capacity. In other words, each meter has a different ratio between the force impelling it forward and the friction of the moving parts holding it back. The friction in each meter may vary widely and the impelling force or torque may do the same. Consequently, there are different ratios between friction and torque for each individual meter.

The continued accuracy of any meter depends primarily on preserving permanently the ratio between torque and frictional counter torque. The variable quantity in this ratio is the frictional counter torque, hence the torque should be so large in proportion that a doubling or trebling of the friction would have no appreciable effect on the accuracy of the meter. For example, suppose the ratio existing in a given meter on a given load be 1 to 100; then by doubling the friction the ratio becomes 2 to 100. In the first case the error would be one per cent, in the second 2 per cent. On the contrary, if the first ratio on the same load were 1 to 10, doubling the friction would make an error of 20 per cent in the reading of the meter, instead of 2 per cent as in the second ratio. Carrying on this process, multiplying each friction by ten in both ratios would give a 10 per cent error in the first one and a complete stoppage of the meter in the second.

The torque of a meter armature remains constant for a given load on the meter, but necessarily varies with the load; hence, if the ratio is 1 to 10 at 10 per cent of the capacity of the meter it becomes 1 to 100 at full load. Therefore, the percentage by which the meter runs slow at full load may be read as a multiplier of the friction; for instance, 8 per cent slow means an increase of friction of eight times the original amount. It is assumed in this statement that the meter ran properly originally and became slow through increase in friction. Meters can run slow from other causes, but these causes are not at present under discussion.

In order to present more clearly the effect of the ratio of friction to torque, a meter of 5 amperes capacity is selected for illustration. For the sake of analysis, the friction: torque ratio of the meter is assumed to be as stated in the second column of the following table:

Load.	Friction: Torque ratio.	Per cent. Slow.
10 lamps = 100%	1:50	2%
5 lamps = 50%	1:25	4%
2½ lamps = 25%	1:12½	8%
2 lamps = 20%	1:10	10%
1 lamp = 10%	1:5	20%
8-c.p. lamp = 5%	1:2½	40%
Stopped. 2%	1:1	100%

In order to avoid such a poor showing as the above, a friction compensator is introduced which theoretically compensates for the friction and enables the meter to run correctly under all loads. Since this friction compensator is not automatic in its operation, that is, does not increase as the friction increases, it affords only imperfect relief, as the increasing of the frictional torque by 10 would stop the meter on 20 per cent of its full load. The remedy lies in decreasing the friction: torque ratio. If the friction remains the same, the doubling of the torque in the foregoing table would result in the following:

Load.	Friction: Torque.	Per cent. Slow.
Full	1:100	1%
Half	1:50	2%
Quarter	1:25	4%
20%	1:20	5%
10%	1:10	10%
5%	1:5	20%
2%	1:2	50%

Increasing the friction by 10 in this instance would stop the meter on 10 per cent of its load and make it 10 per cent slow on full load, instead of 20 per cent slow on full load as under the conditions assumed for the previous table.

Carrying out this principle, one could get a meter that for all commercial considerations would be correct through all ranges of load. One of two things (or both) must be done to accomplish this result, namely, increase the torque or reduce the friction. The most economic course is to eliminate friction, as this keeps down the power consumption of the meter. When the frictional equivalent is reduced to its minimum for a given form of construction, the friction: torque ratio at full load for any meter should not be less than 1:400. This ratio with no friction compensator gives a 2½ per cent error on 10 per cent of full load, which is close enough for commercial use; it would mean an error of 1.2 watts with one light burning on a 5-ampere meter.

It is evident from the foregoing that there is an economic limit to the increase of the torque of a meter with a view to obtaining greater accuracy. When this increase in torque is directly proportional to the increase in current necessary to produce it, it is possible to consume more power in obtaining extreme accuracy than the amount of power lost through inaccuracy. If the ratio 1 to 400 were halved, making it 1 to 800, and this entailed increasing the power consumption of the meter by 3 watts, nothing would be gained; on the contrary, a loss would be sustained of 1.8 watts on any load the meter registered.

By assuming a fixed frictional equivalent, the most economical torque of any meter can be worked out. If all meter losses, for example, amount to 5 watts, the meter should have a resultant torque approaching as closely as possible its mechanical equivalent, or about 1/150 horse-power. As a rule meters are very inefficient, considered as motors, and cannot be otherwise from their construction.

In a 500-watt meter, assume that the friction has been reduced to its lowest possible limit and that the meter consumes at full load 6 watts in its shunt and field coils. With this consumption of energy, also assume the friction: torque ratio to be 1:100. The meter if uncompensated would lose 1 per cent, or 5 watts, at full load from friction. If 8 watts were consumed by the meter and the torque thereby increased by 33⅓ per cent, the friction; torque ratio would be 1:133⅓, and the error at full load would be 3¾ watts. If 9 watts were consumed by the meter and the torque thereby increased by 50 per cent, the friction: torque ratio would be 1:150, and the error at full load would be 3⅓ watts. The net gain, therefore, would be only .417 watt, so this ratio of 1:150 could be assumed to be about the point of economical balance, beyond which there would be no gain in further increasing the torque at the expense of further loss of power. Where the friction is an absolute fixed quantity, the friction: torque ratio of any given meter may be worked out in the same way.

A good method of determining the friction: torque ratio of a given meter is as follows: Adjust the friction compensator on no load so that the meter is just balanced, that is, so it will creep under the slightest vibration. When this is done, turn on the full capacity of the meter and take the speed of the meter under full load; then remove the friction compensator and note the difference in the speed of the meter under the same load. The percentage of slowness will be equal to 100 times the friction: torque ratio; thus, 2 per cent would mean 1:50; 1 per cent, 1:100, and so on. When the friction: torque ratio is determined, it is very easy to figure out the gain or loss that the consumption of additional power to increase the torque would entail.

Meters with ratios over 1 to 400 are the rule rather than the exception, but their frictional equivalent is such that it is impossible to better them. Many meters fail in commercial service by having an unstable frictional equivalent, through faulty mechanical design or improper protection of the revolving parts from foreign elements.

Meters vary in the amount of power required in their potential circuits, and also the amount used in the field windings. The values of these combined amounts should be taken at full load of the meter and a tabulated set of friction: torque ratios put down. The ratio for a given loss of power can be found by ascertaining the loss in registration at full load of the meter caused by the friction and compensating for this by giving the meter more torque at an increased expenditure of energy. From the tabulated values it is a simple matter to select a friction: torque ratio that cannot be decreased unless more energy is expended than will be saved by the increased accuracy obtained.

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ELECTRIC MANUFACTURE OF STEEL.

BY GEO. E. WALSH.

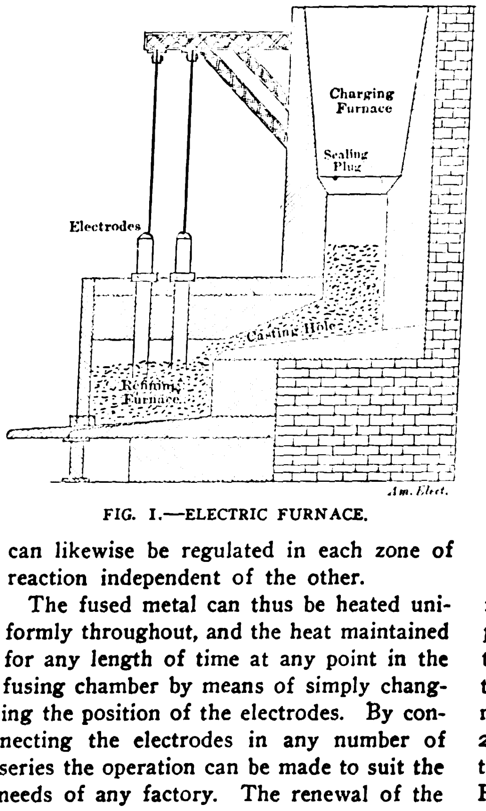
The electrical manufacture of steel from the open-hearth variety to the finest tool steel, represents the latest phase of a wonderful series of electrometallurgical operations which have been carried on in parts of Europe and this country. The principles of manufacture of carborundum, carbide of calcium, artificial graphite and aluminum in the electric furnace are well known, but the treatment of iron ores is still somewhat in the experimental stages. In France more has been accomplished in electro steel making than in any other country, and the forms of furnaces employed, and the different methods of the process, furnish abundant material for study and experiment. The installation of a plant for electric steel making in the Lake Superior iron ore region has been considered by a number of capitalists, and in that region where abundant water power and excellent iron ore can easily be obtained this new manufacturing work may soon develop.

One of the earliest and most progressive factories in France for the manufacture of steel with the electrical furnace was established at Kerrousse, in the Department of Morbihan, France. There are others at St. Etienne, at La Praz, and on the outskirts of Paris. The first factory, however, with its electrical power of 550 horse-power derived from the waterfall of Blavet, has in operation several furnaces for the treatment of iron which are worthy of careful study as representative of what can be accomplished in this direction. Different types of furnaces are used for the manufacture of different ferro alloys and for the manufacture of steel.

The first type of furnace was established in 1889 for the manufacture of calcium carbide, and was commonly called the "two-electrode furnace." It was while experimenting with this furnace for the manufacture of alloys that improvements were made which finally led to the modern electric blast furnace for the treatment of steel. This early furnace is still in operation.

The electric blast or cupola furnace is unlike the "blast furnace" employed for so many years in steel making, since there is no blast whatever to operate it, and the whole process of working it to fuse the metals is purely electrical. It practically consists of two distinct furnaces, the upper one for receiving the ores and carbon for reduction, and the lower for refining the metal.

The upper furnace is built of solid masonry, with a refractory hearth of the ordinary type. The floor inclines toward the casting hole at the bottom, and it is surmounted by a column of masonry into which the ores are fed. In order to secure continuity of operation the electrodes are used in series so that an almost unlimited capacity for reduction can be obtained. The electrodes are consumed as the operation is carried on, the size and capacity of the furnace depending upon the number placed in parallel. At the Kerrousse factory the upper or blast furnace is arranged in two groups, with two electrodes in each placed vertically and in parallel. The two groups are then connected in series, and the fusing of the ore is carried on until these are all consumed, allowing for two or more renewals of the charge without shutting down. The electrodes are placed in the same cavity into which the ores are poured, and when the current is turned on it passes down one electrode, through the ore, and out by the other electrode. Each electrode has its own distinct zone of high temperature, and this can be lowered or changed to suit the operator, and the temperature can likewise be regulated in each zone of reaction independent of the other.



Am. Elect.

FIG. I.—ELECTRIC FURNACE.

The fused metal can thus be heated uniformly throughout, and the heat maintained for any length of time at any point in the fusing chamber by means of simply changing the position of the electrodes. By connecting the electrodes in any number of series the operation can be made to suit the needs of any factory. The renewal of the electrodes in parallel on the same pole is comparatively easy without stopping the smelting work.

When the electrodes are placed in position in the furnace the shaft of the upper furnace is filled with the iron ore, the carbon for reduction and the fluxes. When the current is turned on the separate zones of high temperature can be watched by studying the four ammeters and the two voltmeters which are put in circuit for that purpose. The fusion of the ore begins at the bottom, and works upward and toward the sides of the chamber. The escaping gases from the chamber are carried to an upper chamber where they are used for other purposes, such as operating some auxiliary part of the plant.

The lower furnace is connected with the upper by means of a hole through which the fused metal enters. A cast of the metal in the lower furnace is made after several hours of operation. When it is carried into the lower or refining furnace, the sealing plug is introduced in the ordinary way, and then the two distinct operations of fusing and refining the metal can be carried on simultaneously; that is, the upper furnace can be refilled with new ore, and the lower one operated for finishing off the cast metal. The electrodes of the upper furnace are once more lowered to their initial position, and the slag is emptied through an opening in the side arranged for it. When the upper furnace is thus emptied, and the electrodes arranged for a renewal of the fusing operation, the shaft is again filled with the ore.

The upper and lower furnaces receive their current from two alternators, and when the lower furnaces is filled with the cast metal the work of refining begins. In this furnace the current of electricity produces complete liquefaction and rapid reaction. The lower furnace is supplied with the same electrical equipment as the upper one, and after the introduction of the refining and purifying materials the current is turned on. The process of refining is then the same as in an ordinary blast furnace. It is determined by examination and ordinary metallurgical processes. When finally purified to the satisfaction of the operator, the electric current is lowered in strength, the metal run off into ladles, and the furnace prepared to receive another supply from the upper one.

In the electric blast furnace at Kerrousse nearly all kinds of iron ore have been fused and treated successfully in this way. Scrap iron as well as the plain ores has been treated without any difficulty, and the results were satisfactory. The questions of vital importance in the manufacture of steel by the electrical method are the relative cost of the operation compared with the ordinary open-hearth and Bessemer processes, and the quality of the steel produced. According to the tests made at the Kerrousse factory, it was estimated that to manufacture one ton of steel from ordinary iron ores required the expenditure of 2800 kilowatts per hour, or about 3800 electrical horse-power. At the factory in France the cost of electrical energy was estimated at $10 per kilowatt-year of 8400 hours. Including the cost of the electrodes, coke, ore, refining materials and general expenses, the cost of manufacturing a metric ton of 2204 English pounds ran from $18 to $20. Where the electric current, and the cost of ores and materials are cheaper this cost would be greatly reduced. According to the French figures coke used for reduction purposes was an expensive item, costing $8 per ton delivered, while normally it can be obtained in the steel manufacturing districts of this country for $3 and $4 per ton. Likewise, the cost of the iron ore was considerably more than in many parts of the United States, amounting to $2 per ton delivered, averaging 55 per cent of metallic iron. On the other hand, the labor item is smaller in France than in this country, amounting in the estimates to only 60 cents per day.

The working quality of the steel produced at Kerrousse has been found to be equal to that produced in the ordinary mills operated by the open-hearth or Bessemer processes. It was subjected to all of the mechanical tests applied to steel, and it stood them satisfactorily. The cost and quality of the steel being thus verified by continued tests and operations, the owners of the Kerrousse factory are now building a larger plant for electric steel making.

In this new plant an improvement will be made upon the old one in the shape of portable electric refining furnaces. This is intended to simplify the work by making one refining furnace do the work of a series of electric blast furnaces. In building the fusion and refining furnaces, one over the other, the manufacturers had no examples to follow, and were compelled to find out by experience any difficulties in the work. In operation the upper furnace is called upon to do far more work than the lower. Consequently, the refining furnace is idle a good deal of the time, waiting for the cast metal prepared for it.

The electric portable refining furnace is to be built on a heavy truck running on a track in front of the series of electric blast furnaces. This refining furnace will be built large enough to accommodate the whole battery of blast furnaces. As an economical factor in the process it is unquestionably a great advance on the old method. The portable furnace is built in the form of a huge ladle, which is inserted under the hole of the fusion furnace, and the electrodes lowered to begin the refining process. As the ladle is easily and quickly adjustable to any of the furnaces, the process is carried on continuously before the different blast furnaces.

Fan Motors for 1903

The list of electric fan motors available this year does not show a great number of changes in comparison with last year's production. A few manufacturers have discontinued making this type of motor, and a few others have entered the field for the first time; those who have been in the field for several years past have not modified their product conspicuously, the little machines having long since been developed to a point where substantial improvements are practicable only in minor details.

The line of fan motors manufactured by the Fort Wayne Electric Works this year does not differ importantly from last year's line. Both the direct-current and alternating-current motors have a spherical contour which gives the machines a very graceful appearance. This is shown in Fig. 1, which illustrates a suspended direct-current fan motor; the motor proper of this machine being exactly the same as that of the desk fan motor. The field magnet is built up of stamped laminations, the shape of which is clearly indicated by Fig. 2, which shows a complete magnet with its coils, ready for insertion in the spherical shell.

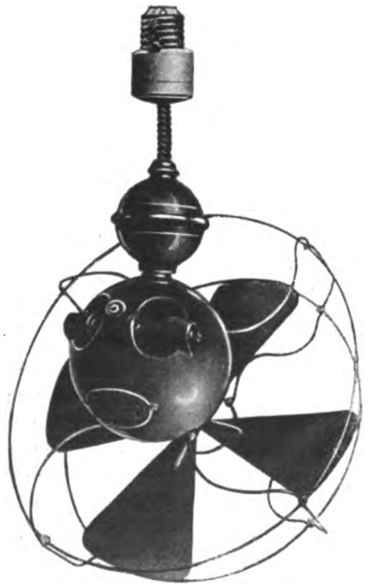


FIG. 1.—FT. WAYNE DIRECT-CURRENT MOTOR.

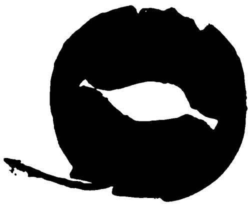


FIG. 2.—DIRECT-CURRENT FIELD MAGNET.

The laminations are individually japanned before being assembled, and are riveted together with German silver rivets in order to reduce to the lowest possible degree the flow of eddy currents through the rivets. The magnet poles are stamped with projecting tips, and the coils when pulled into place and bent into the shape shown in the engraving, are drawn into the recesses above the pole tips. The field magnet coils are form wound with silk-covered wire, and the coil is shellacked, baked and taped.

The armature is of the familiar drum type, with the disks twisted on the shaft so as to give the slots a slightly spiral course from end to end of the core, as indicated in Fig. 3. The armature coils are form wound, taped, shellacked and baked before being assembled on the core; the wire is silk covered. The core slots are lined with an insulating fabric. The commutator is separate from the armature and is assembled complete with its insulation and thoroughly baked before being finally finished and mounted on the armature shaft. The brushes are rectangular in cross-section and located in brass tubes, in which they are fed toward the commutator by means of helical springs. Adjustment of the spring tension is provided in a screw set in the outer end of each brush tube. The bearings are cast from magnolia metal under heavy pressure, and may be readily removed. They are self-oiling, of course, and provided with felt oil retainers which require refilling only at reasonable intervals.

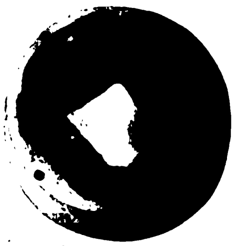


FIG. 6.—ALTERNATING-CURRENT FIELD MAGNET.

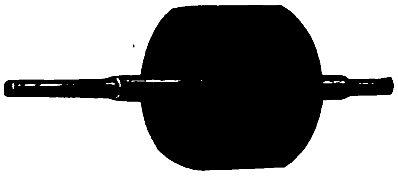


FIG. 7.—FT. WAYNE ROTOR.

The suspended fan shown by Fig. 1 is of the revolving type which the company brought out last year. The body of the fan revolves slowly on a ball bearing located within the small spherical case shown immediately above the body of the motor, which case also contains sliding contacts that deliver current to the motor. Fig. 4 shows a vertical cross-section through this part of the outfit. The rotary motion of the fan is due to the fact that the body is set with the armature shaft at an agle of 45 degrees with the vertical axis of suspension. This puts the upper fan blades further away from the axis of suspension than the lower blades, and this fact, together with the fact that the backward pressure that the fan exerts against the axis of suspension is ex-

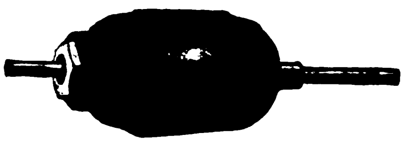


FIG. 3.—ARMATURE.

FIG. 4.

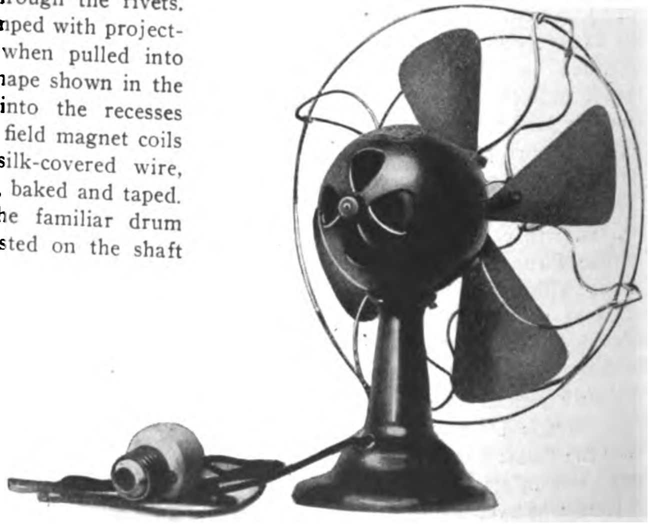


FIG. 5.—FT. WAYNE ALTERNATING-CURRENT MOTOR.

erted obliquely, causes the whole motor to revolve about the axis. The rate of rotation is from 30 to 40 r. p. m. with a fan the shaft of which is running at 2000 to 2200 r. p. m. This type of motor may be suspended, of course, from any convenient fixture, such as a bracket or one of the sockets of an electrolier. The direct-current motors are also mounted on a pedestal exactly as shown by Fig. 5, which illustrates the alternating-current desk fan. The direct-current machines require 17 watts and are wound only for 115 volts.

The Fort Wayne alternating-current motors are built in two types, one a squirrel-cage induction motor for 140 cycles or thereabouts, and the other a series commutator motor for 60 cycles. The field magnets of both types are, of course, laminated. The high-frequency machine has four poles, each provided with a shading coil, as indicated in Fig. 6, which shows a complete magnet ready to be mounted in the casing. The disks of the rotor or armature are twisted around the shaft so as to spiral the slots, as shown in Fig. 7, and the conductors consist of uninsulated copper rods connected in parallel as usual by a conducting ring at each end of the core structure. The field magnet and the armature of the high-frequency alternating-current motor are exactly similar in general construction to those of the direct-current machine shown by Fig. 1, and the magnet coils are connected in series with the armature, as in the case of the direct-current machine. The brushes and brush-holders are also of the same type as those in the direct-current machine. Both the alternating-current and the direct-current motors are provided with 8-in. 4-blade fans, and the spherical casing which encloses the motor is of aluminum. The power required by the alternating-current machine is 20 watts for the 60-cycle motor, and 40 watts for the high-frequency motor. All of the machines run at 2200 r. p. m., when subjected to the normal voltage.

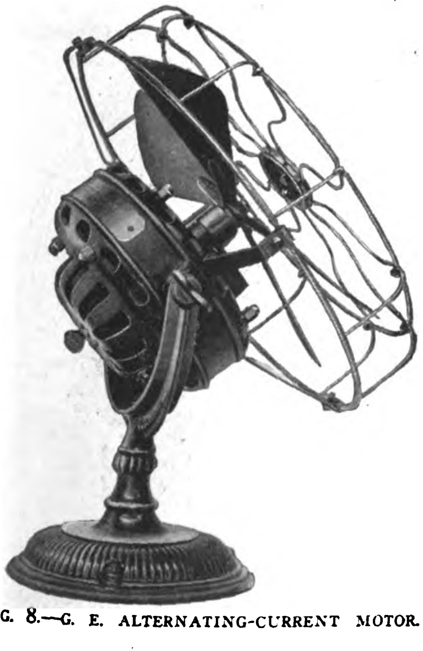


FIG. 8.—G. E. ALTERNATING-CURRENT MOTOR.

All of the General Electric alternating-current fan motors are of the induction type. Fig. 8 shows the exterior appearance of the 12-in. swivel and trunnion alternating-current motor built for 60 cycles and for frequencies between 125 and 140 cycles, and the usual voltages. The field magnet is of the four-pole laminated construction, provided with shading coils, as shown by Fig. 9, and the armature or rotor is of the familiar squirrel-cage type shown by Fig. 10; the rotor conductors are uninsulated. These motors are also built with swivel bases for adjustment around a vertical axis only, and the 16-in. fan of this type is built with a solid frame devoid of any adjustment. Fig. 11 illustrates the swivel construction and also shows the arrangement of the rotor shaft and bearing. As the engraving clearly shows, the shaft is hollow and revolves about a stationary spindle, the bearing extending practically the full length of the rotor shaft. The extension at the back of the motor casing contains a regulating device consisting of a 6-point reactance coil connected in series with the stator winding.

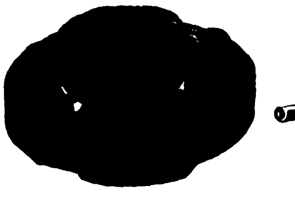


FIG. 9.—FIELD MAGNET.

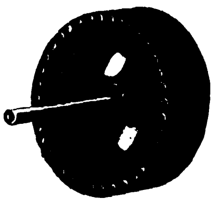


FIG. 10.—ROTOR.

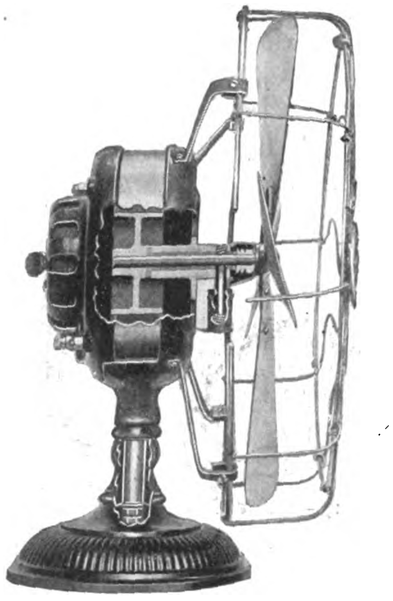


FIG. 11.—G. E. SWIVEL ALTERNATING-CURRENT MOTOR.

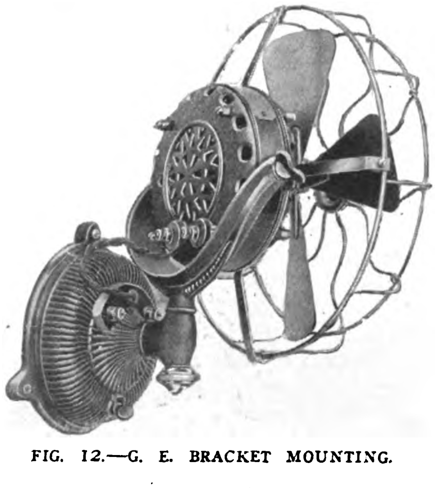


FIG. 12.—G. E. BRACKET MOUNTING.

Fig. 12 illustrates the bracket form of mounting for the swivel and trunnion alternating-current motor. In this case the regulating device is mounted within the bracket base, which accounts for the difference in the appearance of the motor casing. The normal running speeds of these motors are 900 and 1550 r.p.m., and the power consumed is 75 watts at full speed and 51 watts at 900 r.p.m. The speeds of the 16-in. machines are 900 r.p.m. and 1400 r.p.m., and they require 145 watts and 180 watts, respectively, at the speeds mentioned.

Fig. 13 illustrates a new form of suspension bracket brought out this year for use in conjunction with the General Electric propeller fan motors wherever it is desirable to support a motor on a thin wooden partition or similar backing which might act as a sounding board, with disagreeable results. As the engraving shows, the mounting consists of a simple bracket and four helical springs by means of which the body of the motor is suspended from the end of the bracket.

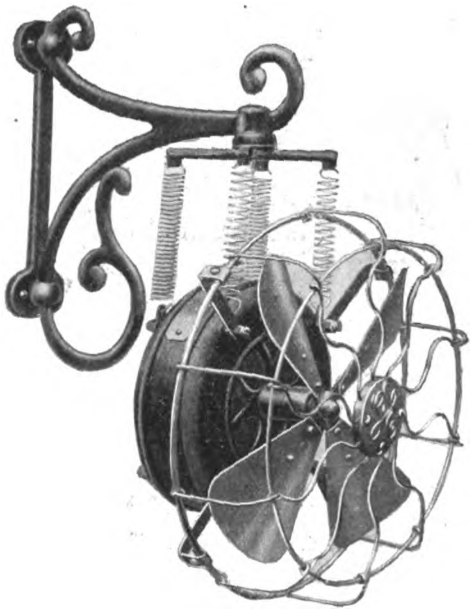


FIG. 13.—G. E. SUSPENDED MOTOR.

The direct-current desk fan of the General Electric Company is provided with a bipolar laminated field magnet held in a thin cast-iron casing by means of four bolts. The armature core disks are twisted on the shaft like those of the Fort Wayne motor in order to reduce the disturbance of the magnetic field, where the teeth of the armature core enter the field and to reduce humming. Fig. 14 shows one of these armatures complete with the commutator. The brushes and brush holders are easily accessible by removing the back cap of the motor regular running condition, as shown by Fig. 15. The brushes are of unusually large size, and are fed through brass boxes by casing, which leaves the interior entirely

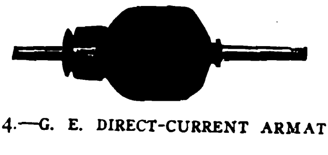


FIG. 14.—G. E. DIRECT-CURRENT ARMATURE.

exposed, while the motor itself remains in regular running condition as shown by Fig. 15. The brushes are of unusually large size and are fed through brass boxes by means of spring-actuated brass fingers pivoted so that the tips of the fingers describe a rather flat arc, to the center of which the axis of the brush is tangential. Fig. 16 illustrates the complete fan with swivel and trunnion mounting. Three running speeds are made available by means of a rheostat and switch mounted within the pedestal base. Fig. 17 shows the under side of the porcelain disk on which is mounted the regulating switch. These motors are built with 12-in. and 16-in. fans, and are also built with bracket mounting. The speeds of the 12-in. fans are 900, 1200 and 1600 r. p. m., and the power required is 32 watts, 41 watts and 51 watts, at the respective speeds named. The 16-in. fan runs at 800, 1100 and 1500 r. p. m., and requires 60, 80 and 100 watts, respectively, at these speeds. Both sizes are wound for 115 and 230 volts.

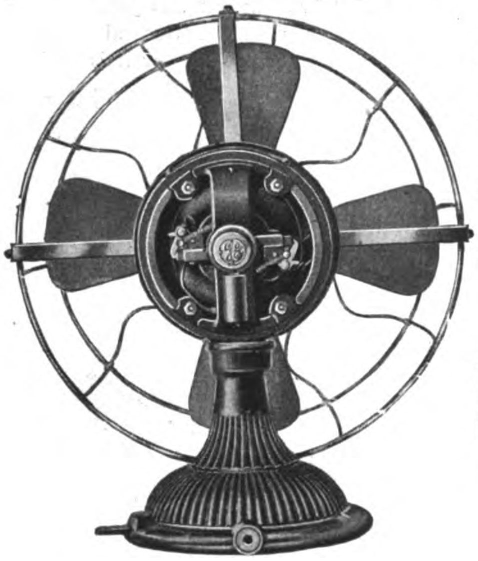


FIG. 15.—MOTOR WITH CAP REMOVED.

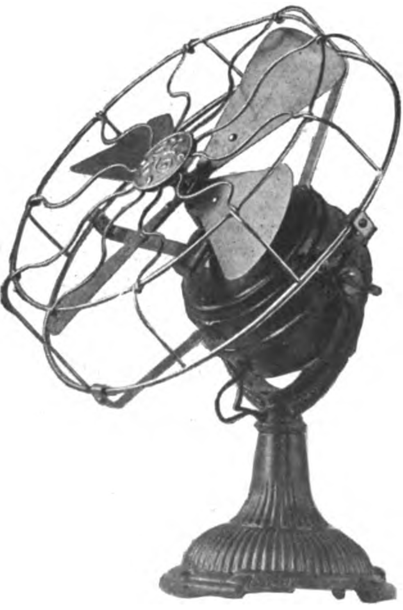


FIG. 16.—G. E. DIRECT-CURRENT MOTOR.

Fig. 18 illustrates a special form of fan motor, which was brought out last year. This is known as the "radial" fan, the distribution of the air being substantially radial to the axis of the machine. This distribution is accomplished by means of the curved deflecting plate shown immediately beneath the fan blades; the fan revolves so as to throw the air downward against the deflecting plate. The motor, of course, is mounted in the semi-spherical casing near the base of the standard. The maximum speed is 2000 r. p. m. and the machine is wound only for 115 volts. It is intended chiefly for use at banquets and similar services.

The General Electric ceiling fan motor is illustrated by Fig. 19. The blades have a sweep of 58 inches, and the machine may be operated at any one of three speeds. The motors built for 115 and 230 volts run at 125, 160 and 200 r. p. m., and the 500-volt machine runs at 140, 170 and 200 r. p. m. All these motors take 108 watts at full speed.

The Westinghouse Electric & Manufacturing Company has brought out a new line of fan motors this year, both direct-current and alternating-current. Fig. 20 illustrates the direct-current desk fan motor and Fig. 21 the corresponding bracket form of machine. The motor has a cast-iron bipolar field magnet, the yoke ring forming the chief part of the casing; the magnet poles are cast integral with the yoke. The magnet coils are form-wound and insulated with silk tape; Fig. 22 shows the field magnet with the coils in position and one end cap removed. The armature (shown complete by Fig. 23) is hand wound, silk-covered wire being used; the armature core slots are heavily insulated with treated cloth, which is put in place, of course, just before the coils are wound into the slots. Carbon brushes of square cross-section are used, and they are fed to the commutator in brass tubes into which they fit very snugly. The brushes may be removed and renewed without disturbing the end cap of the motor casing, the removal of a cap on the outer end of the brush tube allowing the brush and spring to be taken out. The bearings are self-aligning and are lubricated by means of felt wicks, which feed oil upward from the cups, the latter being located beneath the bearings. The machine is a simple series-wound motor, speed regulation being obtained by the use of a rheostat and switch, in the well-known manner. A slight

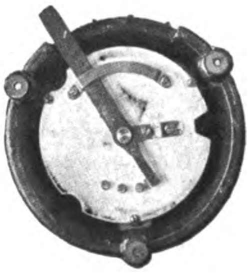


FIG. 17.—SWITCH.

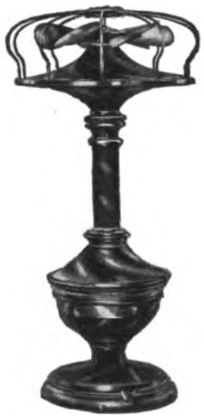


FIG. 18.—RADIAL FAN.

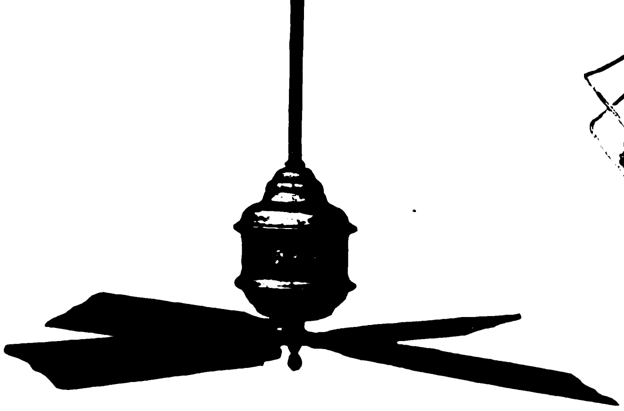


FIG. 19.—G. E. DIRECT-CURRENT CEILING FAN MOTOR.

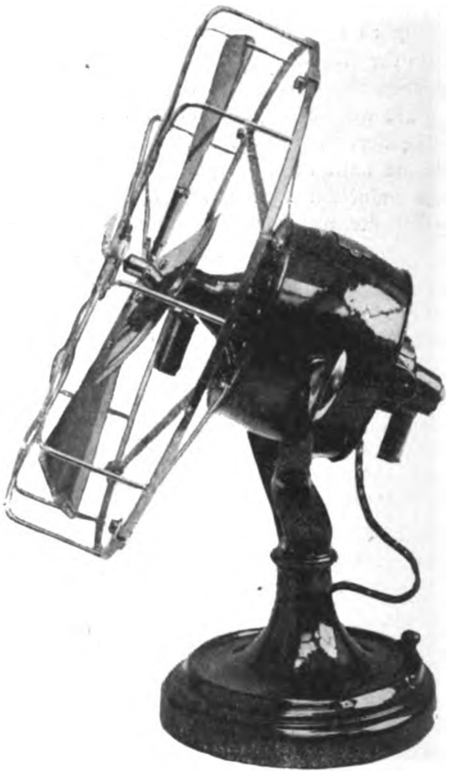


FIG. 20.—WESTINGHOUSE DIRECT-CURRENT MOTOR.

FIG. 21.—WESTINGHOUSE BRACKET MOTOR.

divergence from common practice consists in placing the resistance coils within the field magnet frame; the switch is located in the base of the pedestal, as usual. These machines are made with 12-in. fans, and have two speeds, 1000 and 1550 r. p. m. The power consumption is 27 watts at the lower speed and 44 watts at the maximum. They are wound for 110-120 volts only.

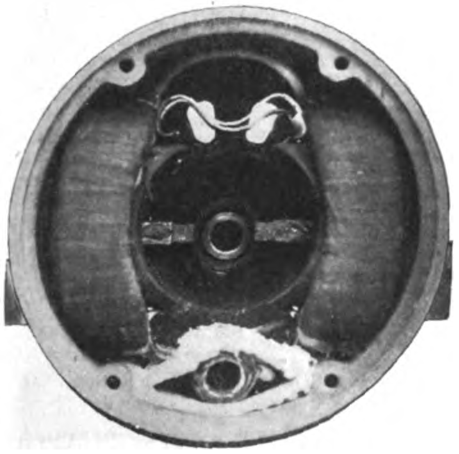


FIG. 22.—WESTINGHOUSE DIRECT-CURRENT FIELD MAGNET.

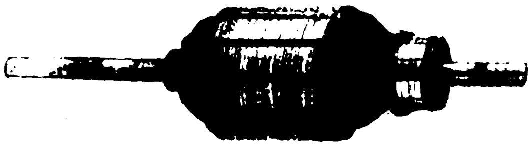


FIG. 23.—DIRECT-CURRENT ARMATURE.

The Westinghouse alternating-current fan motor is an induction motor of the ordinary squirrel-cage type. Fig. 24 illustrates desk form and Fig. 25 the bracket form. The mounting in both forms is the swivel and trunnion, exactly like the direct-current motor just described. Fig. 26 shows the interior of the motor, with the rotor in position, and Fig. 27 shows the rotor alone. It will be noticed that the diameter of the rotor is unusually large with respect to its axial length, giving a very high torque at the shaft with a given field strength, as compared with a rotor of smaller diameter and greater length. The machine shown by Fig. 26 is the 133-cycle motor, and therefore has a large number of poles—ten. The field magnet embodies no very unusual features. It consists of a yoke ring with integral poles, laminated, of course, and mounted in a light cast-iron casing; the 60-cycle motors have four poles. The magnet coils are form wound and insulated with silk tape.

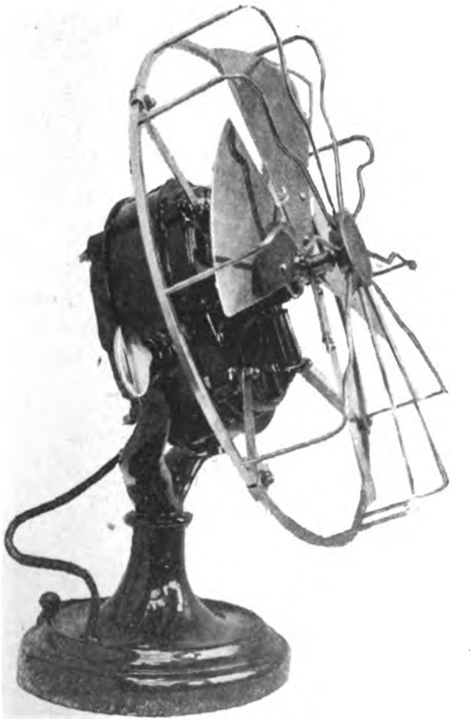


FIG. 24.—WESTINGHOUSE ALTERNATING-CURRENT MOTOR.

The rotor conductors are bare copper rods, with their ends soldered into heavy rings at the ends of the core. There is only one bearing, which is located between the rotor core and the fan, and this is lubricated in the same way as the bearings of the direct-current motor. These machines are built with 12-in. and 16-in. fans, and for 100-120 volts at each of the frequencies mentioned above. The 12-in. 60-cycle fan requires 60 watts at low speed (which is 1000 r.p.m.) and 85 watts at full speed (1550), the 12-in. 133-cycle fan runs at 1200 r.p.m. on 50 watts and at 1350 r.p.m. on 65 watts. The speeds and power requirements of the 16-in. 60-cycle fans are 1000 and 1550 r.p.m. and 145 and 180 watts, respectively; the 133-cycle fans of this size run at 1200 r.p.m. on 87 watts and 1450 r.p.m. on 103 watts. The two speeds are secured by cutting in or out part of the field magnet winding, a switch for this purpose being located in the base of the pedestal.

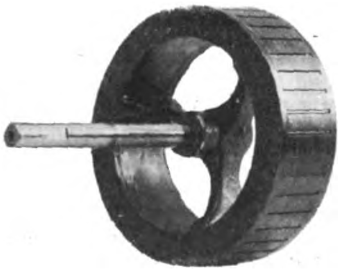


FIG. 27.—ROTOR.

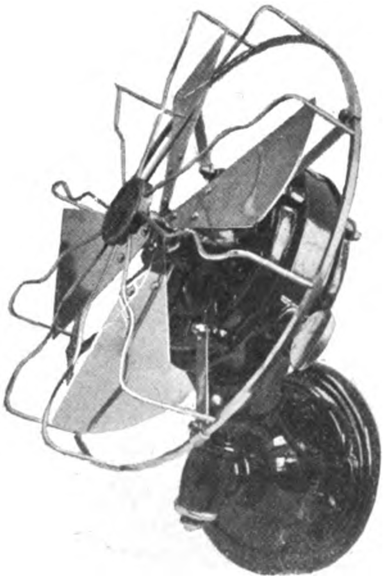


FIG. 25.—ALTERNATING-CURRENT BRACKET MOTOR.

Fig. 28 illustrates the very compact direct-current desk fan motor built by the Jandus Electric Company, and Fig. 29 shows the machine with the protecting caps removed. The field magnet is bipolar, and built up of soft steel punchings. The magnet coils are form wound, taped and varnished, and are connected in series with the armature, as usual in this class of machine. The armature is of the usual slotted type, but the coils are form wound and are insulated before being put in the slots. The brushes and brush-holders are of the cartridge type, but the brush cross-section is rectangular. The speed-regulating rheostat consists of resistance wire wound on an enameled tube and mounted in the pedestal base. The bearings are of the wick-oiling type, as shown in the sectional view in Fig. 30. These motors are wound for 100-120 and 200-250 volts, and have three speeds. The 12-in. fan runs at 900, 1200 and 1600 r.p.m. and takes 44 watts at maximum speed; the 15-in. fan runs at 900, 1150 and 1525 r.p.m. and requires 65 watts at full speed; the 16-in. fan runs at 800, 1050 and 1400 r.p.m. and takes 75 watts at full speed.

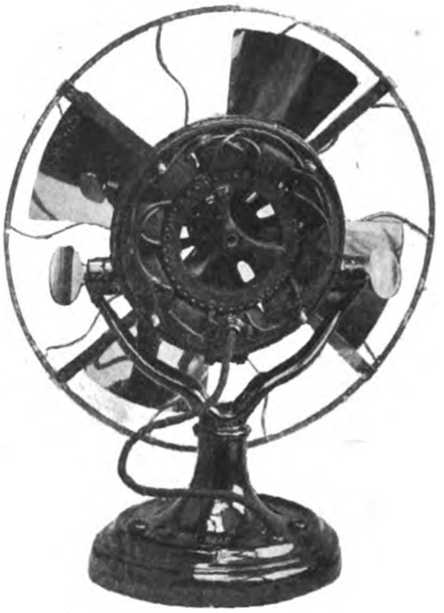


FIG. 26.—WESTINGHOUSE TEN-POLE FIELD MAGNET.

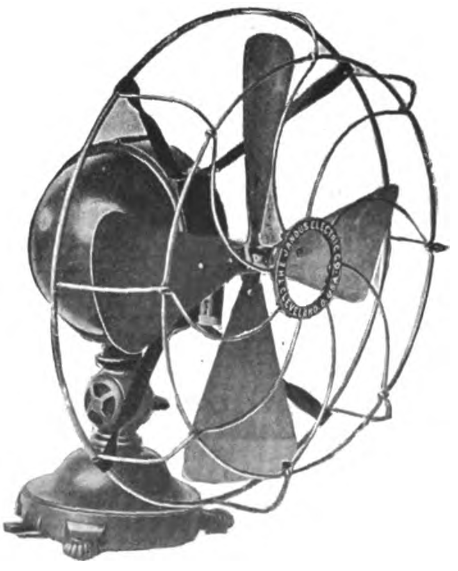


FIG. 28.—JANDUS DIRECT-CURRENT MOTOR.

The Jandus Company also builds an alternating-current fan motor very similar in construction and appearance to the direct-current machine. It is built for 60 and 133 cycles and for 104 volts and thereabouts. Speed regulation is secured in the alternating-current motors by means of a switch in the base which connects the field magnet coils in series or parallel, according to the speed desired. The fan diameters are the same as those of the direct-current machines. Both classes are provided with the swivel and trunnion mounting shown in Fig. 31, which enables the user to change the motor pedestal from desk to bracket form by merely turning the base up through an angle of 90 degrees and screwing it to the wall or other vertical support. Fig. 32 shows a method of mounting that the Jandus Company has brought out this year. Two desk fans are seated on a bracket which is adapted to revolve about the axis of the hanger stem, and the motors are set at such an angle that the reactive effort of the fans causes the whole to revolve. The bracket may also be locked in any position and the fans adjusted to throw air continuously in any direction. This arrangement is designated the "Gyrofan"; it is also furnished with an ornamental electrolier beneath the revolving bracket when desired.

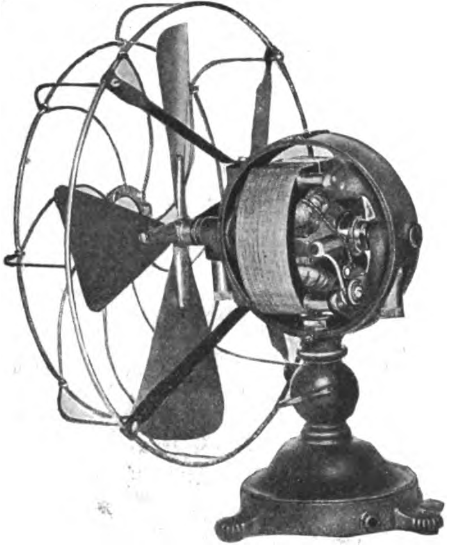


FIG. 29.—JANDUS MOTOR WITH CAPS REMOVED.

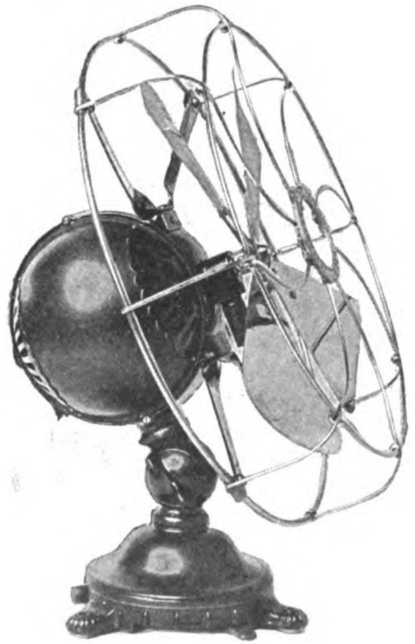


FIG. 31.—JANDUS ALTERNATING-CURRENT MOTOR.

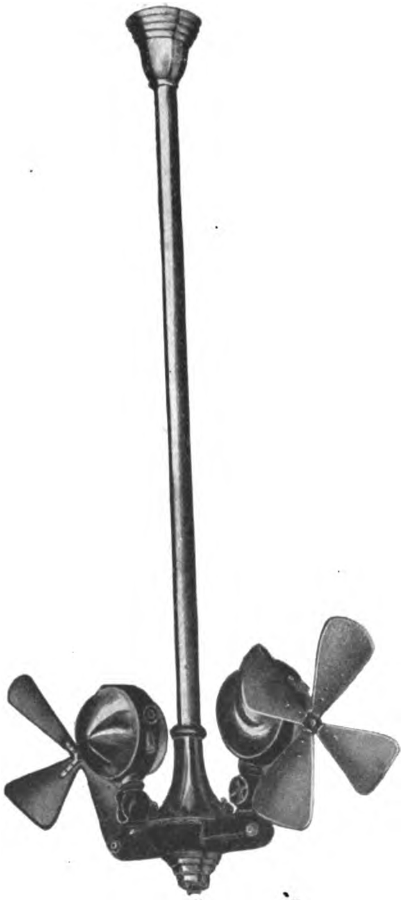


FIG. 32.—"GYROFAN."

The general appearance of the Western Electric Company's desk fan motor for 1903 is similar to that of the well-known type of the past year. Fig. 33 is an external view and Fig. 35 a cross-sectional view of the machine. The field magnet is of the inverted horseshoe type, which style of construction allows a low pedestal and small enclosing castings to be used, thereby making the weight of the motor unusually low, as a large proportion of the material is "working material." The weight of the motor is further reduced by the use of a forged steel field magnet. The armature is of the slotted drum type, wound with double silk-covered wire, which is insulated from the core by pressboard tubes in the slots and pressboard discs over the end plates. The field magnet coils are wound on pressboard spools, and being exposed to the direct action of the moving air, an exceptionally low-running temperature is obtained. The large diameter of the armature, the forged steel field magnet, field coils of small diameter cooled by moving air, a short air-gap and careful shaping of pole tips, give the motor a high efficiency.

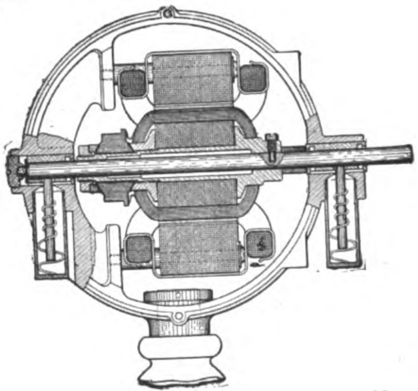


FIG. 30.—SECTION OF JANDUS MOTOR.

The commutator is made of hard-drawn copper segments, separated by best mica insulation. The bearing bracket enclosing the commutator end of the armature is of such a form as to furnish ample protection from any dirt or dust falling upon the fan, but it is sufficiently open to allow the commutator to be readily inspected. The bearing brackets contain babbitt sleeves and are provided with lips which overhang flanges on the commutator cap and on the fan hub to prevent the throwing of oil. From the recesses in the bearing brackets formed by the lips, the oil is drained back to the oil cups through ducts in the castings. A cap covers the end of the shaft and bearing and prevents leakage of oil and entrance of dust.

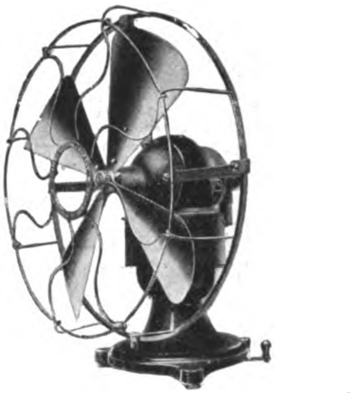


FIG. 33.—WESTERN ELECTRIC DESK FAN MOTOR.

The brushes are of specially prepared graphite, circular in cross-section, and self-adjusting. The brush holders are a modification of the cartridge type and are provided with triggers which bear upon the ends of the brushes, pressing them against the commutator. They allow almost the entire brush to be used up, and as there is no clamping, the brushes are not likely to break. The brushes can be readily renewed without disturbing any of the electrical connections.

The speed-regulating rheostat consists of an iron drum upon which is wound German silver wire, embedded in and protected by a complete coating of white enamel, so as to eliminate any possibility of short-circuiting or grounding on the adjacent frame. The drum is mounted on a porcelain base carrying the speed-regulating switch and binding posts, and located within the pedestal.

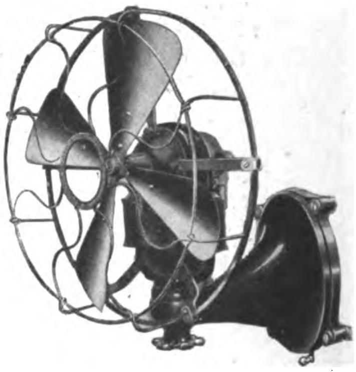


FIG. 34.—WESTERN ELECTRIC BRACKET MOTOR.

These motors are wound for operation on standard direct-current circuits of 110, 220 and 500 volts. The field magnet coils are connected in series with the armature for all voltages. This type of motor is also made with the bracket form of mounting, as shown in Fig. 34. The fan can be turned to any desired position by the adjustment of a single hand screw, and the adjustment can be made while the fan is running at full speed. The motor frame swivels upon a ball and socket joint and has a horizontal range of adjustment of 180° and a vertical range of 45°.

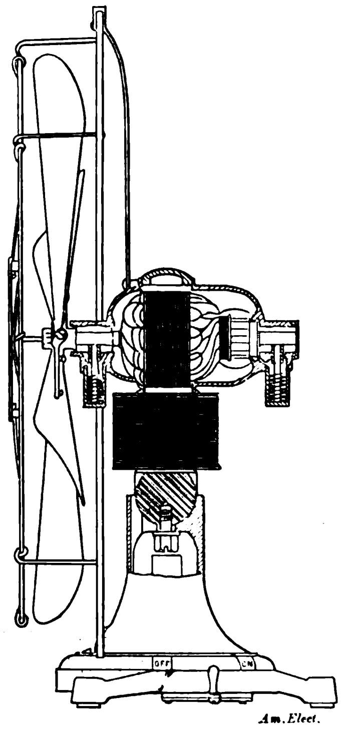


FIG. 35.—CROSS-SECTION OF WESTERN ELECTRIC DESK MOTOR.

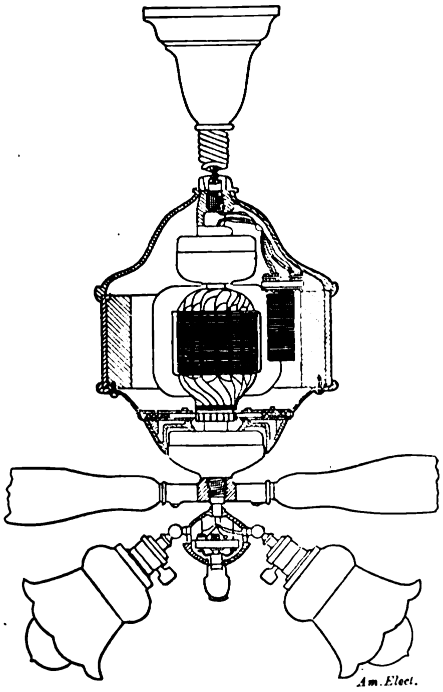


FIG. 36.—WESTERN ELECTRIC STANDARD CEILING MOTOR.

The Western Electric Company's ceiling fan motors are shown by Figs. 36, 37, 38 and 39. Fig. 36 is a cross-sectional view of the Western Electric Standard ceiling fan. The motor is bipolar and has a slotted drum armature, the core being mounted directly on the shaft. The yoke ring and magnet poles are one casting of semi-steel. The armature winding is of double silk-covered wire wound in round holes and insulated from the core by pressboard tubes and end discs. The field magnet coils are wound in four sections, each section being thoroughly insulated with a double wrapping of heavy insulating tape dipped in Sterling insulating varnish. As in the desk fan motor, the armature is of large diameter in order to obtain a large number of slots and coils which affords a high efficiency and at the same time sparkless operation.

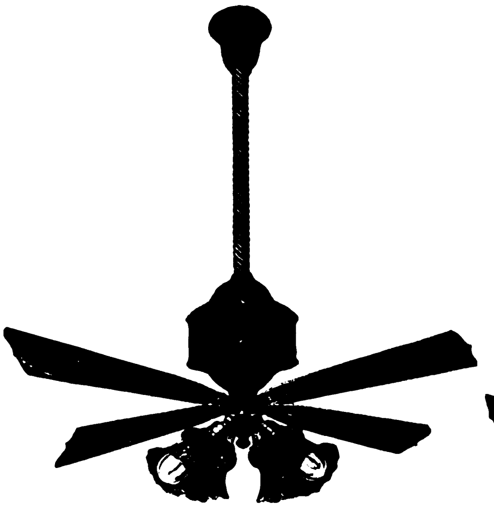


FIG. 37.—WESTERN ELECTRIC STANDARD CEILING MOTOR.

The Western Electric Standard ceiling fans are equipped with non-spillable oil reservoirs, which flood the bearings constantly with oil. The well is partly covered and a flange extends from the top of the well nearly to the surface of the oil, somewhat like an invertible inkstand, and this prevents the oil from spilling when the motor is laid on its side or even inverted. There is left a sufficient opening around the shaft to allow thorough washing of the well with benzine at the end of the season. The brushes and holders are of the cartridge type, and the brushes are graphite pencils, each pressed toward the commutator by a helical spring behind it. The spring is designed to give a constant pressure to the brush until it is almost entirely used up.

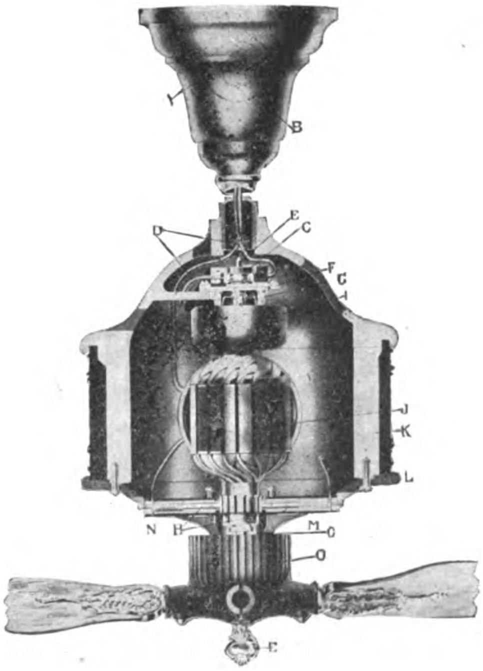


FIG. 38.—SECTIONAL VIEW OF WESTERN CEILING MOTOR.

The weight of the motor is supported by a strong cast-iron bracket fastened to the frame with machine bolts. The bracket also supports the upper bearing and a steel tube extending through the armature shaft, which is hollow. This tube contains a six-wire cable, including the wires for the chandelier lights and the wires connecting the speed-regulating rheostat to the switch. The rheostat, which gives three speeds to the fan, is made of German silver wire wound on an iron drum, the wire being imbedded in a coating of white enamel. The rheostat is mounted on a porcelain base screwed to the cast-iron bracket. The base serves as a connection board, having six binding posts for connections of the chandelier lighting leads and rheostat leads.

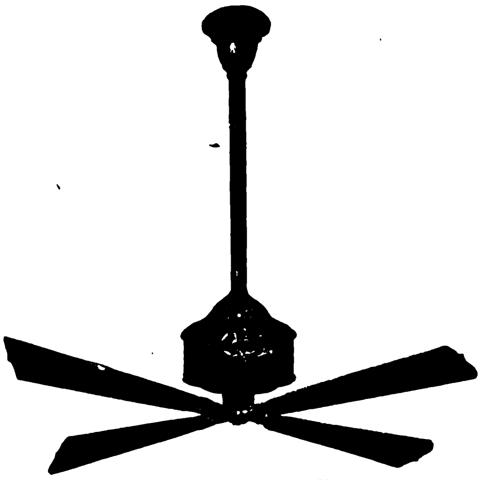


FIG. 39.—WESTERN CEILING MOTOR.

The upper cover can be removed to get at the upper oil well and the connection board without taking the fan from the ceiling hook. The bearings are of babbitt and are self-aligning. The large wearing surface of the journals and bearings and rigid method of mounting the bearings make it practically impossible for the armature to be drawn against the pole-pieces on account of imperfect alignment or wearing of the bearings.

The blades are of the finest quality of white basswood, thoroughly seasoned and free from blemish. The sweep of the blades is 60 in., and the width across the face is 8¾ in. They are pitched to give an unusually large wind output, while the input is only 120 watts. The speed is 210 r.p.m. These motors are wound for 110, 170, 220, 250 and 500 volts; the 170-volt and 250-volt motors are intended to run in groups of three and two, respectively, in series on 500-volt circuits, in which case a wall switch rheostat for three-speed control is furnished.

Figs. 38 and 39 illustrate the Western Electric Company's Western ceiling fan for 1903. Fig. 38 is a cross-sectional view of the Western No. 1 ceiling fan, while Fig. 39

is a perspective view of the Western No. 2 fan. The two styles are similar in all respects with the exception that the No. 2 is not provided with a starting switch. Both are single-speed fans. The motor is bipolar and has an armature similar to that of the Standard ceiling fan. The yoke is of the best soft cast-iron, to which forged steel magnet poles are bolted. The poles have extended tips. The field magnet coils are wound on pressboard spools, giving a large polar angle, which, together with the use of a field coil of small diameter, permits very compact construction and promotes high efficiency in the motor. The brackets supporting the upper bearing and switch and the upper covering to which the suspension rod screws, are cast integrally with the frame. The Western fans are equipped with oil reservoirs, but they do not have the non-spillable feature of the Standard oil wells, although the method of lubrication is the same. Before removing the fan from the ceiling hook, the oil should be withdrawn from the wells by means of a small oil pump provided for this purpose. The switch in the upper part of the Western No. 1 fan is operated by a key and a rod extending through the hollow armature shaft.

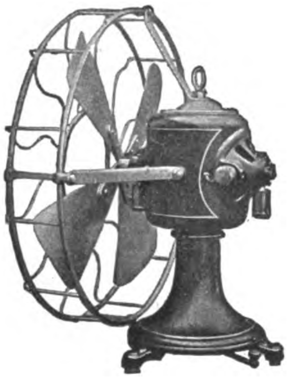


FIG. 40.—STANDARD PARAGON MOTOR.

The Western No. 1 motor is wound for 120, 220 and 500 volts, while the Western No. 2 is designed to operate singly on 110, 170, 220, 250 and 500 volts or in series groups of two 110-volt fans on a 220-volt circuit; five 110-volt fans on a 550-volt circuit; three 170-volt fans on a 500-volt circuit, or two 250-volt fans on a 500-volt circuit. The blades are of white basswood, free from blemish, and have a sweep of 54 inches. The motors run at 200 r.p.m. with an electrical input of 90 watts.

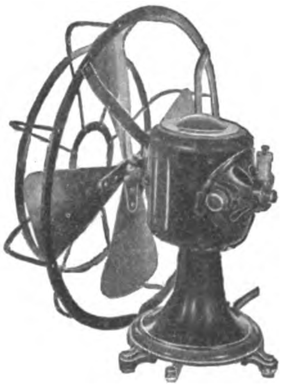


FIG. 41.—PARAGON "BLACK" MOTOR.

Fig. 40 illustrates the standard Paragon desk fan built by the General Incandescent Arc Light Company. The field-magnet of this machine is of cast-iron, the poles and shell being cast in a single piece. The journal bracket at the rear of the machine is removable and the aperture that it covers is sufficiently large to permit the insertion and withdrawal of the field-magnet coils and armature. The magnet coils are machine-wound, covered with two layers of linen tape, dipped in insulating varnish, and thoroughly baked. The armature is of the usual slotted type and the coils are wound into the slots by hand, the slots being of course heavily insulated beforehand. The whole armature is dipped into insulating varnish and baked. The brushes are rectangular in cross-section and contained in holders of the cartridge type. The holders are so mounted in the journal bracket as to permit their removal without disturbing the bracket. Both the commutator and the armature core are assembled under enormous pressure on brass tubes, which are headed over at the ends, making the construction not only solid but permanent. The bearings are of the self-aligning type, with phosphor-bronze sleeves and lubricated by wick-feed oilers.

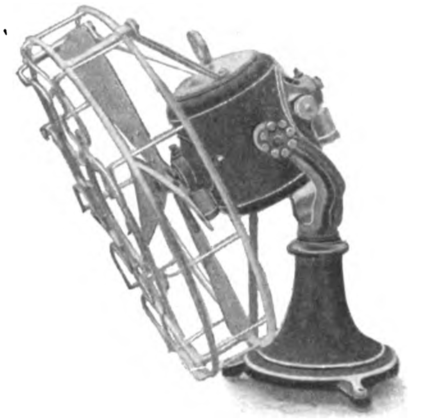


FIG. 42.—PARAGON MOTOR.

Fig. 41 illustrates the Paragon "Black" fan motor, which is new this year. This machine, so far as its running parts are concerned, is precisely like the standard Paragon motor, with the exception of the lubricating device, grease cups being used instead of the wick-feed oil cups of the standard motor. There is also some difference in the shape of the guard, as a comparison of the two illustrations will show. The chief difference between the two fans, however, is purely one of finish, the standard machine being finished in dark green enamel with gilt stripes and polished and lacquered brass work, while the new motor is finished in plain black enamel with dipped and lacquered brass work and an enameled iron fan guard instead of the polished brass one used on the standard fan. Fig. 42 illustrates the adjustable mounting of the desk fan motor, which is of the swivel and trunnion type, and Fig. 43 illustrates the corresponding bracket form of mounting, the slight difference between which and the desk mounting will be obvious at a glance.

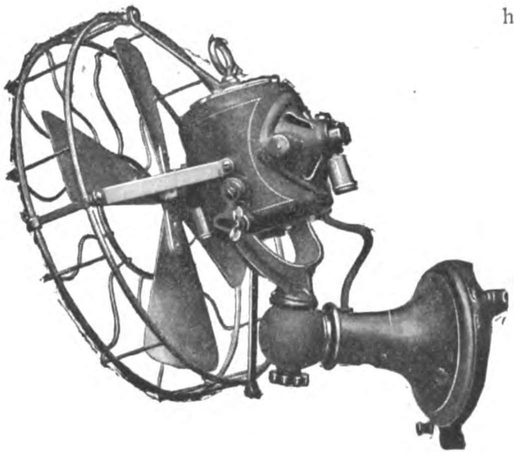


FIG. 43.—PARAGON BRACKET MOTOR.

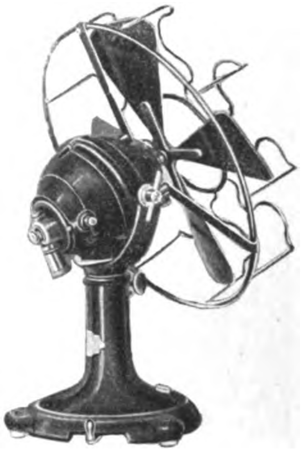


FIG. 44.—LUNDELL MOTOR.

Both the desk and bracket fans are built in 12-inch and 16-inch sizes and wound for the usual standard voltages up to 250 volts. All of the machines are provided with enamel-insulated resistances giving three running speeds. The rheostat is mounted in the pedestal of the machine in the usual manner. The 12-inch fans run at 1700 r.p.m. and require 0.35 ampere at 115 volts and 0.2 ampere at 220 to 250 volts. The 16-inch fans run at 1500 r.p.m. and require 0.6 ampere at 110 to 120 volts, 0.315 ampere at 220 to 230 volts and 0.3 ampere at 240 to 250 volts.

The Lundell 12-inch desk fan, built by the Sprague Electric Company, is illustrated by Fig. 44. The details of the mechanical construction of this machine are so well known as to require no repetition here of the description, which has several times been published. The single field-magnet coil substantially concentric to the armature shaft is retained, together with the cartridge-type brushes and brush-holders and wick-feed oil cups, which have been

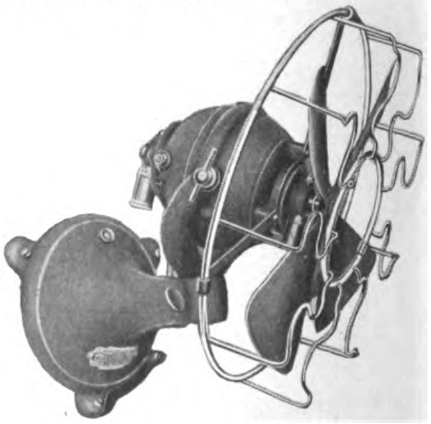


FIG. 45.—LUNDELL BRACKET MOTOR.

used for several years. The field-magnet is of cast-iron in two pieces, and the armature is removable by taking off the rear cap of the frame in which are mounted the brush-holders. Both the field-magnet and armature coils are of double cotton-covered wire and the windings are thoroughly varnished and baked. Fig. 45 illustrates the bracket form of mounting for the same motor, and Fig. 46 shows the bracket mounting of the 15-inch fan motor, which differs from the mounting of the 12-inch machine in that a ball-and-socket universal joint is employed in place of the swivel and trunnion. These machine are made also in 16-inch and 18-inch sizes, and all of the sizes are provided with rigid non-adjustable pedestals at the option of the purchaser.

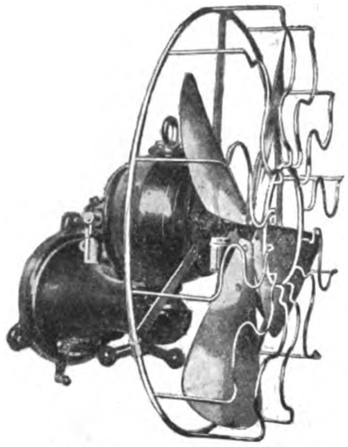


FIG. 46.—LUNDELL BRACKET MOUNTING FOR 15-IN. FAN MOTOR.

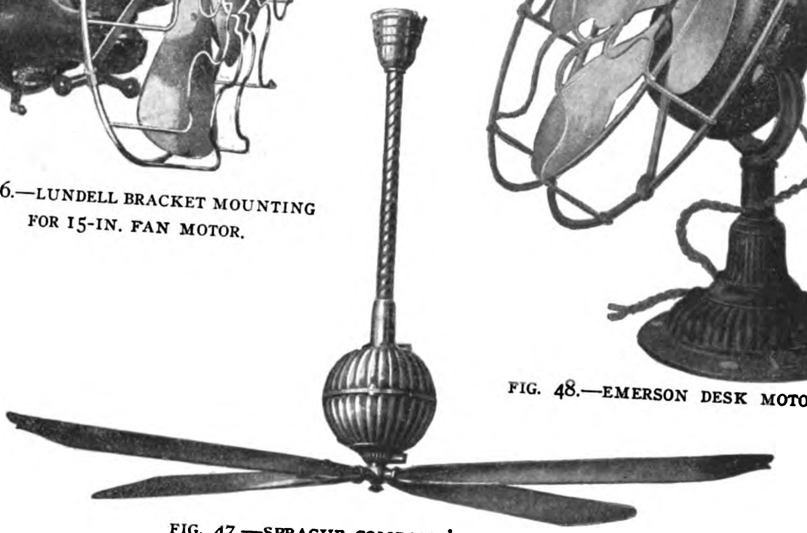


FIG. 47.—SPRAGUE COMPANY'S COLONIAL FAN.

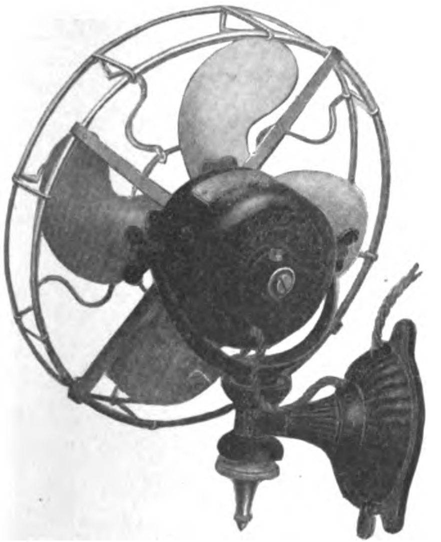


FIG. 49.—EMERSON BRACKET MOTOR.

All of the fans are provided with three speed rheostats and switches. The 12-inch fans run at 800, 1350 and 1900 r.p.m. and require for maximum speed 0.45 ampere at 115 volts and 0.25 ampere at 230 volts. The 15-inch fans run at 600, 1100 and 1500 r.p.m. and for the maximum speed require 69 watts at each voltage. The 16-inch fans run at 800, 1150 and 1450 r.p.m. and require 103 watts at each voltage. The 18-inch fans run at 600, 900 and 1300 r.p.m. and require for full speed 1.1 amperes at 115 volts and 0.6 ampere at 230 volts.

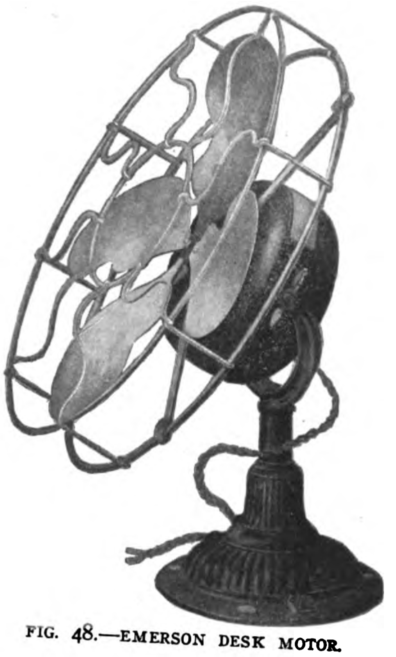


FIG. 48.—EMERSON DESK MOTOR.

The Sprague Company's Colonial ceiling fan motor is illustrated by Fig. 47. The motor of this machine is similar in design to the motor of the desk and bracket fans. It is wound for 115, 165, 230 and 250 volts and runs at only one speed, namely, 150 r.p.m. The sweep of the blades is 56 inches and the width of each blade 9 inches. The motor is provided with a switch, the handle of which projects below the center of the fan-blade hub. This switch merely puts the machine in and out of circuit, no rheostat being employed. The motor requires 115 watts at all voltages. The Sprague Company has discontinued the manufacture of the four-pole Empire ceiling fan motor and of the alternating-current desk and bracket fan motors described last year.

Fig. 48 shows the Emerson Electric Manufacturing Company's two-speed desk fan for low-frequency alternating current (60 cycles), provided with swivel and trunnion mounting. The running speeds are 1300 r.p.m. and 1650 r.p.m., and the current consumption is 45 watts at the slow speed and 55 watts at full speed for the 12-inch size; 90 watts at slow speed, and 100 watts at full speed for the 16-inch size. These machines are wound for all of the standard alternating-current secondary voltages. This type of machine is also built in bracket form, as illustrated in Fig. 49, the only difference being the form of mounting. Fig. 50 illustrates the field magnet and armature of the machine, and shows that the field is provided with "starting" coils, located midway between the working coils, so as to give the necessary auxiliary field 90° from the working magnetic field for starting. The armature or rotor is of the usual squirrel-cage type, as shown in this engraving.

Fig. 51 illustrates the method of lubricating the armature bearings. There is no armature shaft, the armature core being mounted on a bronze drum provided with extensions, *F* and *F*, at each end, which fit around a stationary hollow spindle, *M*, and constitute bearings. The fan is provided with a hollow hub, *J*, screwed on the projection at one end of the armature core-drum, so as to completely enclose the bearing at that end. The outer end of the bearing at the other end of the armature is enclosed by a rawhide washer, *E*, mounted on a portion of the frame, *B*. Lubrication is provided through the oil cup, *A*, the lubricating oil being delivered to the interior of the hollow spindle, *M*, and finding its way through holes, *L* and *L*, to the bearings, *F* and *F*; the hollow fan hub, *J*, catches the oil at that end of the armature, and it is prevented from leaking out at the other end by the rawhide washer mentioned above. A cavity, *N*, within the armature spider, is provided for the retention of a reserve lubricant.

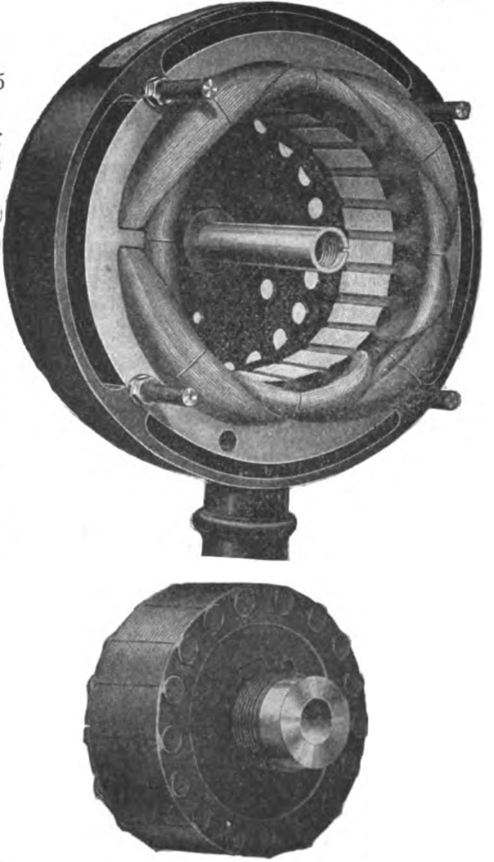


FIG. 50.—EMERSON FIELD MAGNET AND ROTOR.

Fig. 52 illustrates a "residence type" of fan motor brought out this year by the Emerson Company. It is similar in general construction to the machine just described, differing from it only in the speeds, which are 900 and 1100 r.p.m., and in the number of fan blades—6. The 12-inch fan-motor of this type requires 40 watts at slow speed and 50 watts at full speed; the 16-inch machine requires 80 and 90 watts respectively at slow and full speeds. The Emerson Company also builds a full line of desk and bracket motors for 133 cycles and thereabouts. The machines of this type run at 1400 and 1700 r.p.m., at which speeds the 12-inch size requires 60 and 75 watts respectively, and the 15-inch size 90 and 100 watts respectively.

The Emerson ceiling fan for low frequencies has been modified from last year's design, which was improved over the design of 1901. The machine is a single-phase induction motor, with a squirrel-cage rotor, the conductors of which are flat copper strips instead of round rods. It is built for two speeds, being provided with a speed-regulating coil, *G*, Fig. 53, and a regulating switch, *P*. The motor has 28 field-magnet poles, only 14 of which are wound. These 14 poles are provided with slots in the center for the reception of starting coils, which are wound on one-half of each pole, and are put in service only when the machine is first switched into circuit. The peculiar oiling system used heretofore has been retained. This consists of a spiral groove within the hollow armature shaft, which raises oil to the top of the shaft, whence it trickles down again and lubricates the bearing. Fig. 54 is an exterior view of the complete fan, which is made in several sizes, the standard sweeps being 50 and 56 inches. The four-blade 52-inch fan runs at 180 and 225 r.p.m. and takes 110 and 135 watts, respectively, at these speeds. The two-blade 56-inch fan runs at the same speeds, but takes only 100 watts at the lower speed and 125 watts at the higher. Fig. 55 shows the high-frequency ceiling fan-motor. This has a 30-inch sweep and runs at 500 to 600 r.p.m., according to the frequency. It takes 125 watts.

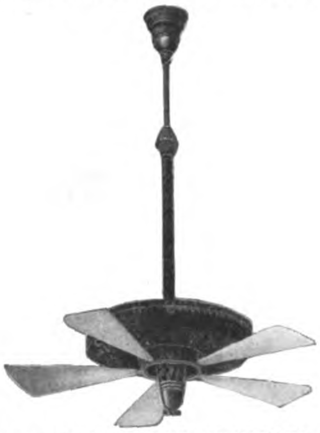


FIG. 55.—EMERSON HIGH-FREQUENCY MOTOR.

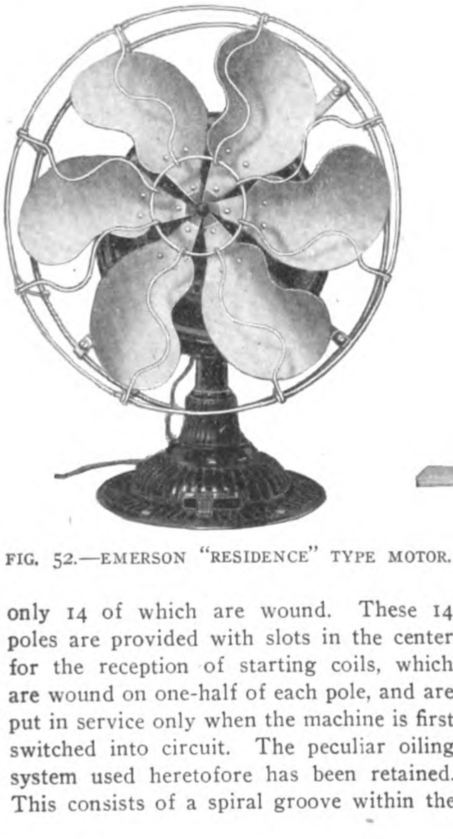


FIG. 52.—EMERSON "RESIDENCE" TYPE MOTOR.

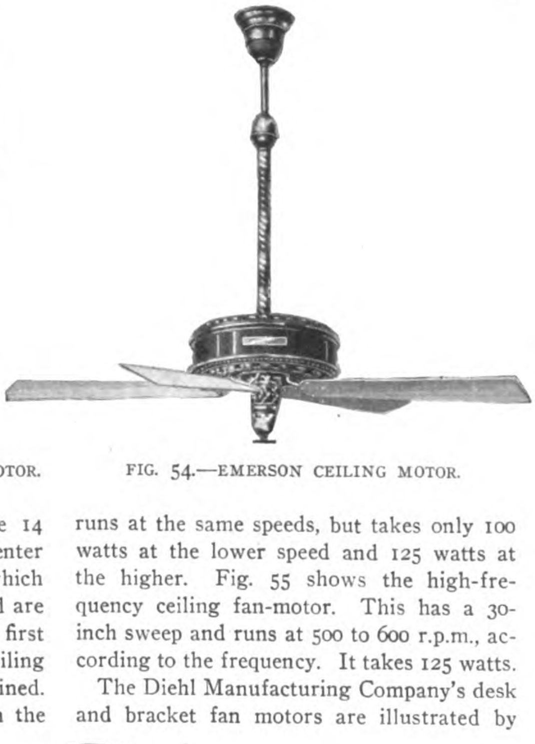


FIG. 54.—EMERSON CEILING MOTOR.

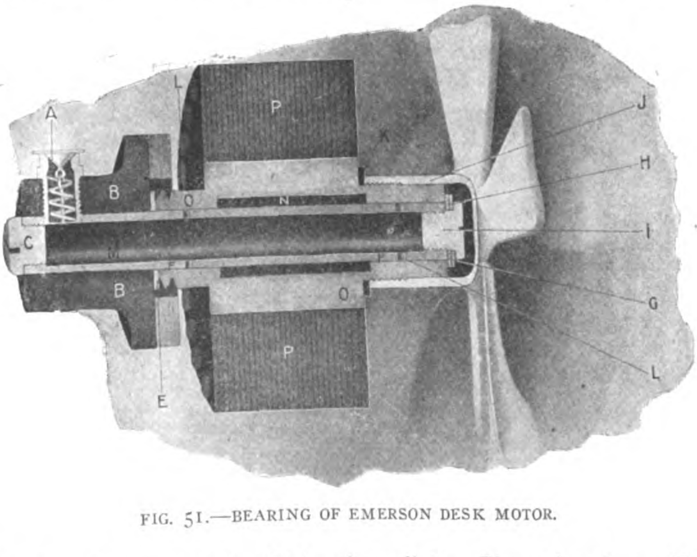


FIG. 51.—BEARING OF EMERSON DESK MOTOR.

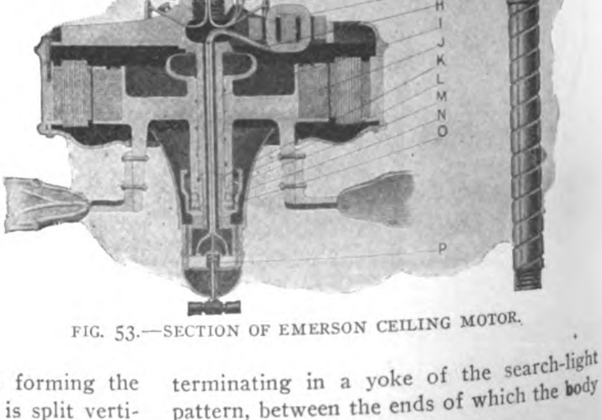


FIG. 53.—SECTION OF EMERSON CEILING MOTOR.

The Diehl Manufacturing Company's desk and bracket fan motors are illustrated by Figs. 56 and 57. The barrel forming the yoke-ring of the field magnet is split vertically in such a plane that the joint does not pass through the core of the field magnet, but only separates the yoke into two parts.

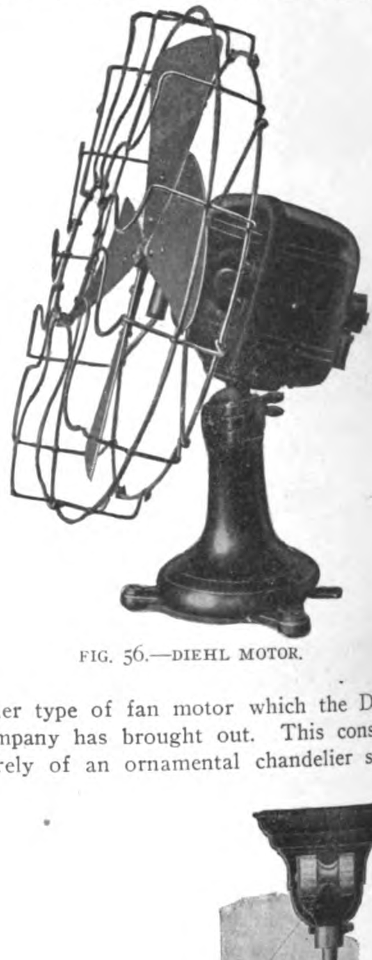


FIG. 56.—DIEHL MOTOR.

This arrangement obviously gives a jointless magnetic circuit, and at the same time provides easy access to the interior of the machine. The brushes and holders are of the pencil and cartridge type, and the brushes are removable by taking off fibre caps on the ends of the holders. As indicated in the engravings, the machines are provided with the usual rheostat and speed-regulating switch mounted in the pedestal. The other details of construction are in conformity with standard modern practice, slotted drum armatures with machine-wound coils, and self-oiling and self-aligning bearings being employed. Fig. 58 illustrates a method of mounting the propeller type of fan motor which the Diehl Company has brought out. This consists merely of an ornamental chandelier stem terminating in a yoke of the search-light pattern, between the ends of which the body of the motor is pivoted.

Fig. 59 represents the standard ceiling fan of the Diehl Manufacturing Company, the motor of which is a bipolar machine with a laminated internal field magnet, the armature being of the Gramme-ring external type. As the engraving clearly shows, a part of the case is attached directly to the armature and revolves with it, and the blades are mounted in sockets on this part of the casing. The internal drum armature ceiling fan motor of the Diehl Company has been changed somewhat from last year's design. This fan is illustrated by Fig. 60. The field-magnet is of cast-iron in a single piece and is provided with machine-wound coils which are heavily taped, dipped and baked before being put in place. The armature is of the slotted drum type; in fact, the whole design of the machine is very similar to that of the desk motor. The coil slots in the armature core are insulated with micanite troughs and the coils are machine-wound directly into the slots.

The Adams Electric Company, Trenton, N. J., has succeeded to the electric fan motor of the Backus Water Motor Company, and has put out this year an improved type of ceiling fan motor which is illustrated in perspective by Fig. 61 and the motor of which is shown in cross-section by Fig. 62. The field-magnet is multipolar and the armature is of the Gramme ring type. The commutator is of the disc pattern and located on the upper part of the armature spider. As Fig. 62 shows, ,there are two cups or receptacles for lubricant, one in the central part of the field-magnet structure and the other consisting of a cup screwed to and revolving with the armature shaft. The armature hub is longer than is usually the case and its lower end is seated in the bottom of the upper grease cavity, forming a step bearing. When the machine is in motion, however, the reaction of the fan blades relieves the pressure on the step to an almost negligible quantity. The brushes and holders are of the cartridge and pencil type and the carbon pencils may be removed without disturbing the holders or the framework of the motor, the holder tubes being provided with detachable caps on their upper

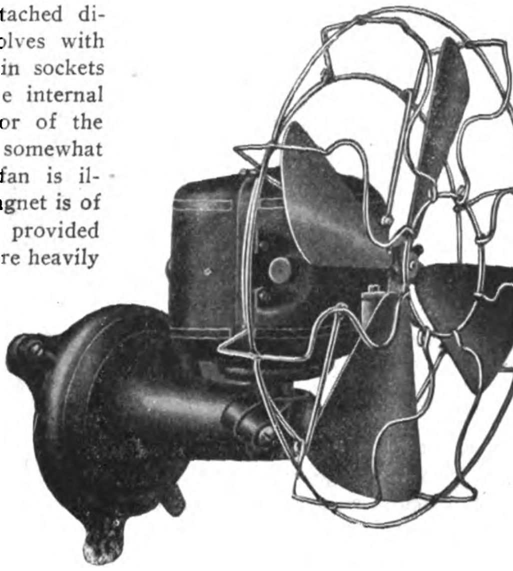


FIG. 57.—DIEHL BRACKET MOTOR.

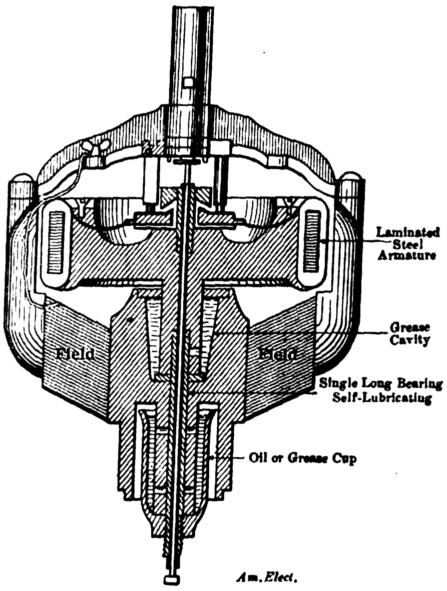


FIG. 62.—CROSS-SECTION OF ADAMS CEILING MOTOR.

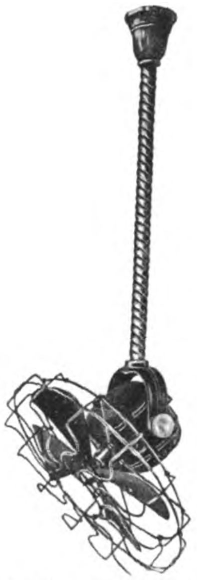


FIG. 58.—DIEHL MOTOR.

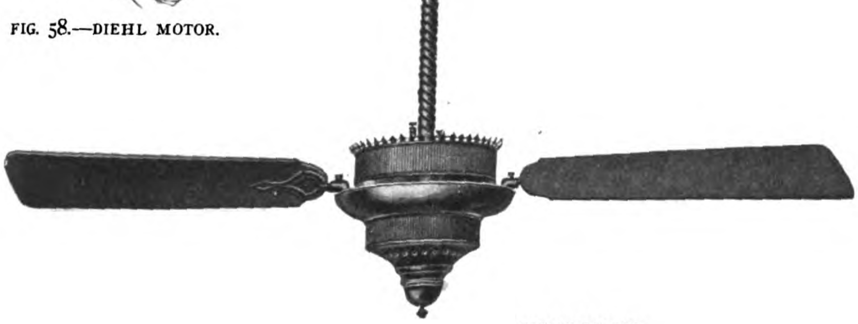


FIG. 59.—STANDARD DIEHL CEILING MOTOR.

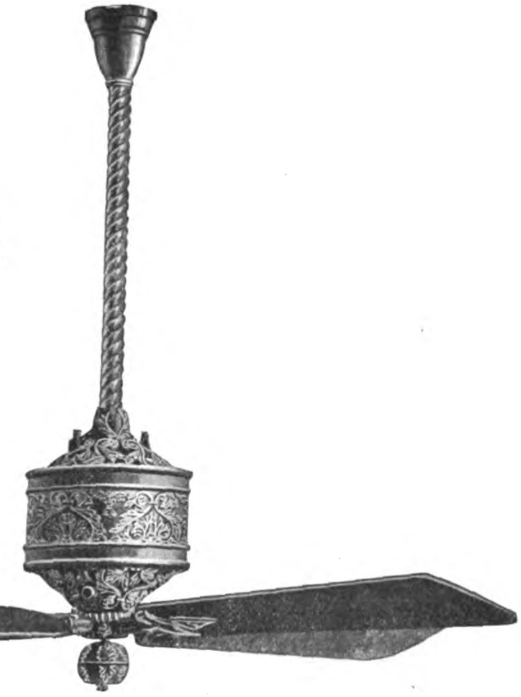


FIG. 60.—DIEHL INTERNAL-DRUM-ARMATURE CEILING MOTOR.

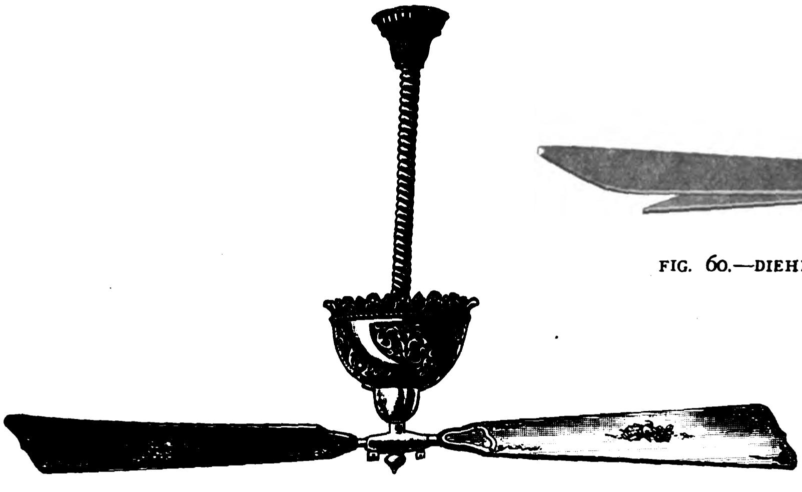


FIG. 61.—ADAMS CEILING MOTOR.

ends. The starting switch is located in the upper part of the motor structure and its spindle passes downward through the armature spider and shaft to a controlling button at the lower end. The motor is wound for 115, 125, 170, 230, 250 and 500 volts.

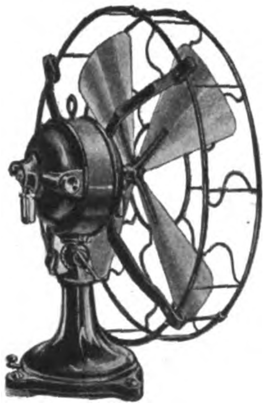


FIG. 63.—ADAMS MOTOR.

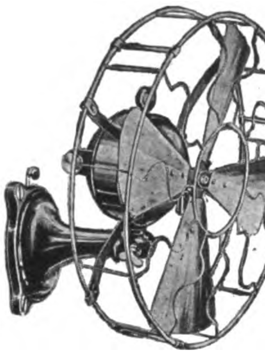


FIG. 64.—ADAMS MOTOR.

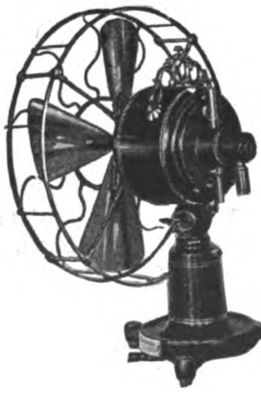


FIG. 65.—ROBBINS & MYERS MOTOR.

Fig. 63 illustrates the desk fan motor of the Adams Electric Company, which may be converted into a bracket motor by merely turning the pedestal up through an angle of 90 degrees to the position indicated in Fig. 64. This machine is bipolar and has the usual slotted drum armature. The brushes and brush-holders are similar in design to those on the ceiling fan motor and are mounted in one of the caps of the motor casing. As in the case of the ceiling fan, the brushes may be removed by taking off caps on the outer ends of the holder tubes. The motor is attached to the pedestal by a double swivel joint which is the equivalent of a universal joint or a gimbal. The vertical swivel is in the yoke ring of the motor, a small screw being provided immediately beneath the circular case to secure the swivel stem after adjustment. The method of adjustment in the other direction will be obvious from a glance at the illustrations. The motors are provided with the usual rheostat and switch located in the pedestal.

The Robbins & Myers Company brought out a new line of desk and bracket fan motors last year, and these machines were so well thought out prior to their advent on open market that no material changes have been found necessary this year. Fig. 65 herewith illustrates the desk motor, and Fig. 66 the bracket style. The motor is a bipolar machine with the usual form of slotted drum armature, but the armature is larger than is ordinarily found in a 12-in. desk fan. The field magnet is of cast iron, in a single piece. The magnet coils are form-wound and insulated before being placed in position. The brush-holder is of the well-known cartridge type, and each holder is mounted in an insulated clamp on the rear end-cap of the motor, as plainly shown in Fig. 65. The connections are made to the clamps so that the brush-holders and brushes may be removed without disturbing the electrical connections and by simply slacking a single screw on each holder. The brushes are 5/16-in. carbon pencils, 1¼ ins. long, and are fed radially to the commutator by piano-wire compression springs. The commutator is thoroughly insulated with mica, and the connecting wires are securely bound to an asbestos insulating ring on the rear collar of the commutator in order to prevent their being broken by vibration or rough handling of the machine. Another notable improvement in the 1902 fan is the form of bearing used. The bearing sleeve is split lengthwise along the top and fits snugly in the hole drilled through the center of the hub or central projection of the end cap. Two screws are set into the end of the hub at such an angle that setting them up draws the split sleeve more closely around the shaft. This adjustment is provided, of course, for the purpose of taking up wear in the journal sleeve. The journals are lubricated by a wick oiler of the usual under-feed type.

Universal adjustment for the desk fan is provided in the form of horizontal and vertical swivels, the horizontal swivel being fastened by means of a thumb nut, and the vertical swivel by means of a set-screw near the top of the pedestal. The bracket fan has similar adjustment, but both swivels are tightened by means of thumb nuts. Both forms are provided with three-speed regulating switches, giving 1000, 1400 and 1800 r.p.m. for the 12-in. fan, and 800, 1150 and 1500 r.p.m. for the 16-in. fan; the regulating switch also serves to break the circuit for stopping the machine. The switch parts are insulated with mica, and the resistance wire is wound on a triangular iron frame heavily insulated with asbestos. The power consumption of these machines ranges from 35 to 45 watts for the 12-inch fan, and from 85 to 95 watts for the 16-inch fan, according to the actual voltage on the various circuits for which the motors are wound. The machines are built for the standard direct-current circuits of 110, 220 and 250 volts. When two or more motors are operated in series, the regulating switches are constructed so that they cannot open the circuit, but the speeds of all of the fans may be regulated, of course, by any one switch, or by two or more in combination.

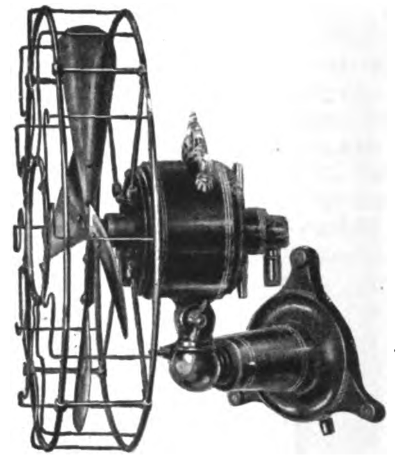


FIG. 66.—ROBBINS & MYERS BRACKET MOTOR.

Fig. 67 illustrates the Robbins & Myers "Style A" ceiling fan motor and Fig. 68 shows the "Style B" machine, the only external difference being in the design of the casing. The constructional details of the motors, however, differ considerably from each other. The Style A machine is provided with a cast-iron field-magnet yoke-ring to which drop-forged steel magnet poles are bolted. The poles are provided with extended tips to increase the area of the air-gap. The motor is bipolar and the magnet coils are form-wound, taped, dipped in Sterling varnish and baked. The field-magnet of the Style B machine is a single iron casting of the shape shown by Fig. 69. This peculiar shape of magnet pole allows the coils to be put in place and removed without necessitating a removable pole or pole-shoe, and still provides polar extensions which nearly double the area of the air-gap. The magnet coils are wound and insulated like those of the Style A machine. Fig. 70 is a cross-section of the

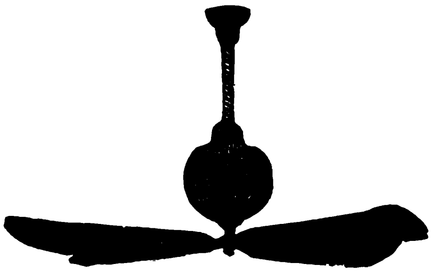


FIG. 67.—STYLE "A" CEILING MOTOR.

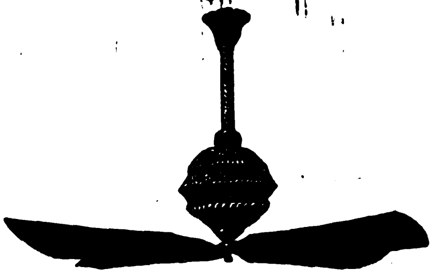


FIG. 68.—STYLE "B" CEILING MOTOR.

Style B motor and shows all of the internal details which are common to both the Style A and Style B machines. In both styles of machine the coil slots in the armature core are insulated by hard fibre troughs 1/64 inch thick, and the armature coils are wound directly into the slots. The 500-volt machines are wound with silk-covered wire; those for lower voltages are wound with double cotton-covered wire. Cartridge brush-holders, containing carbon-pencil brushes, are used in these machines, as in the desk form.

The armature shaft is hollow, in order to permit the switch spindle, *D*, to pass up through it from the thumb piece, *E*, at the bottom of the fan, to the switch, *A*, at the top. The switch, in conjunction with the resistance coil, *B*, gives two speeds to the 110-volt and 220-volt machines. The motor is not furnished with the switch and resistance unless so ordered, the construction being such that the switch and resistance can be inserted or omitted without changing any of the remainder of the structure. Both styles of machine are furnished ordinarily with four fan blades, and are wound for 110, 170, 220 and 250 volts. The 170-volt and 250-volt motors are intended to be operated in series on 500-volt circuits, and when equipped with switches one motor of a series may be cut out without interfering with the other motor or motors.

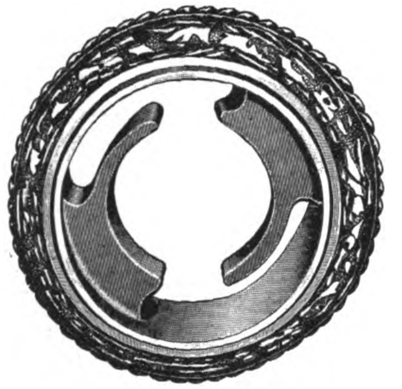


FIG. 69.—FIELD MAGNET STYLE "B" CEILING MOTOR.

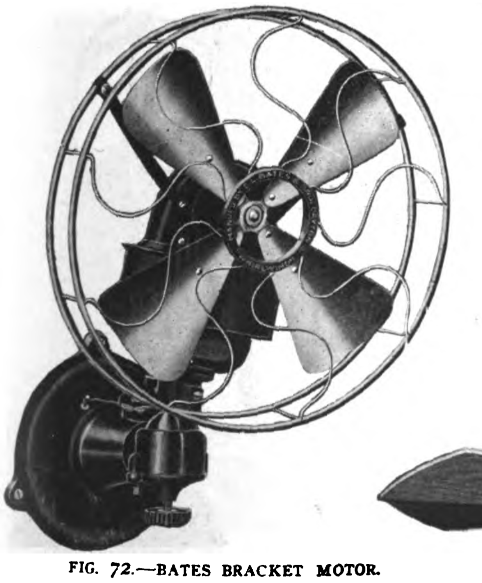


FIG. 72.—BATES BRACKET MOTOR.

The bearings are lubricated by immersion in two large oil baths or reservoirs, the cups of which are mounted on the armature shaft and revolve with it. The basin or cup at the bottom of the shaft is cast solid with the fan-blade hub, as indicated in the engraving.

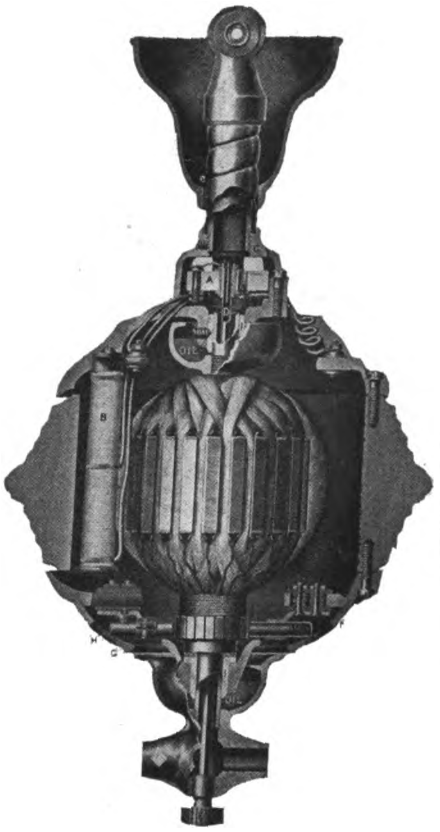


FIG. 70.—CROSS-SECTION OF STYLE "B" MOTOR.

In addition to these machines the company has brought out a standard 500-volt fan, which runs at 200 r.p.m. and requires 0.2 ampere at the rated voltage. The general construction is similar to that of the two fans just mentioned, but more room is provided for the windings in order to permit the use of the extra-heavy insulation demanded by the increased voltage.

Fig. 71 shows the desk fan motor made by the D. L. Bates Brother Company; this is built also with the adjustable form of mounting for desk service. The magnet cores are of forged steel, and the armature is of the usual slotted-drum type. The armature is protected by enclosing caps applied to the magnet poles and containing the journal boxes. These machines are built for 110, 220 and 500-volt circuits. The bracket motor (see Fig. 72) is provided with a universal socket adjustment and the desk motors are built with either a swivel and trunnion base or the solid base shown in Fig. 71. The power consumption of the machines at full speeds is as follows: 12-in. fan at 110 volts, 31 watts; at 220 volts, 44 watts; 16-in. fan at 110 volts, 60 watts; 220 volts, 83 watts, and at 500 volts, 125 watts. All of the fans are provided with three-speed switches, giving speeds of 1500, 1700 and 1900 r.p.m. in the 12-in. size; 1200, 1350 and 1600 r.p.m. in the 16-in. 110-volt machine; 1400, 1500 and 1600 in the 16-in. 220-volt machine, and 1300, 1400 and 1500 in the 16-in. 500-volt machine.

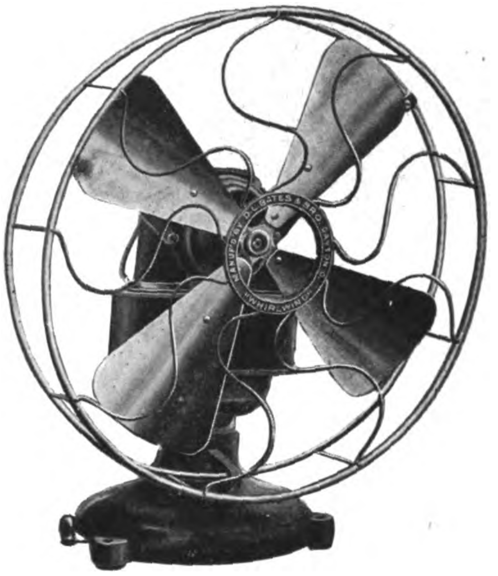


FIG. 71.—BATES DESK MOTOR.

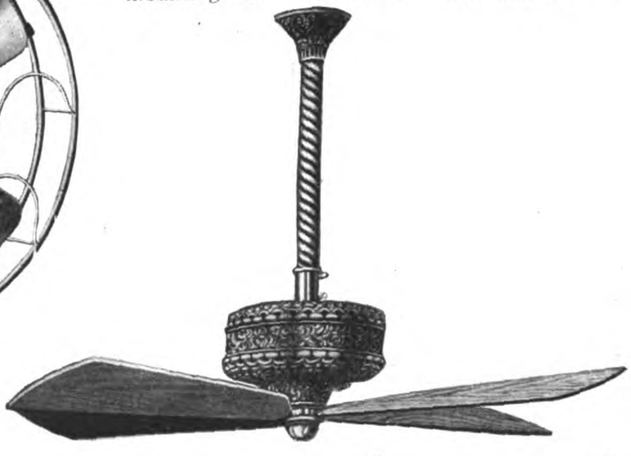


FIG. 73.—BATES STYLE "E" CEILING MOTOR.

The Bates Company has brought out a new ceiling fan this season, which is designated Style E and is illustrated by Figs. 73 and 74. The motor is of the multipolar type, with six field-magnet poles cast integral with the yoke-ring. The magnet coils are wound on fibre spools and wedged in position on the magnet cores. The armature core is slotted and of large diameter, and the coils are form-wound and insulated before being put in the slots. The commutator is built of hard-drawn copper bars drawn to gauge and assembled under hydraulic pressure. The brush-holders and brushes are of the cartridge and pencil type, but the brushes are

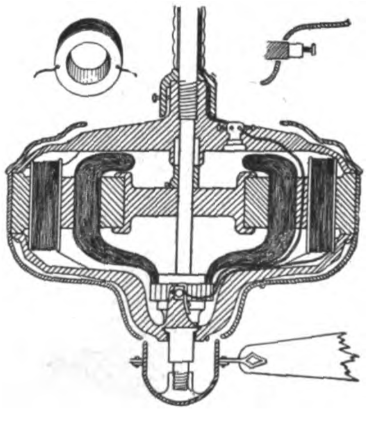


FIG. 74.—CROSS-SECTION OF STYLE "E" MOTOR.

rectangular in cross-section. The holders project through openings in the lower part of the motor casing, so that the brushes may be renewed without dismantling the machine at all. These machines are wound for 110, 167, 220, 250 and 500 volts.

The Peerless desk fan motor, manufactured by the Peerless Electric Company, is illustrated by Fig. 75, and the corresponding bracket form of machine is shown by Fig. 76. This machine is of the usual enclosed form, provided with self-oiling bearings and automatic-feed brush-holders. The field-magnet of the Peerless fan motor is cast of a special grade of imported metal selected after a series of tests made with material submitted by over a dozen of the leading foundry men of the country. The magnet poles are integral with the yoke ring, and are of large cross section, thereby obviating any heating that might be caused by small cross-sections and resultant high densities, requiring high magnetizing force. They are all of the bipolar type with the field windings connected in series with the armature. The coils are form wound and insulated with the best grade of linen tape and then treated with a peculiar insulating compound used in all Peerless motors. The low-voltage direct-current armatures are wound with double cotton-covered magnet wire, and the high voltage armatures are wound with double silk covered wire. The coils are insulated from the armature by oiled linen and after the winding is in place and connected to the commutator it is tested for break-down between the coils themselves and between coils and core, with 500 volts for 110-volt and 220-volt armatures, and 1000 volts for 250-volt and 500-volt armatures. The armature is of the usual slotted-core drum-wound type. The brushes are of the carbon pencil type, and the brush-holders are of the cartridge type, thoroughly insulated from the frame of the machine by heavy fibre tubes extending over half the length of the brush tube. The commutator of every type of Peerless fan, both ceiling and desk, is built up of the best grade of hard-drawn Lake Superior copper bars, machined to shape and insulated with India mica; the same grade of mica is used to insulate the ends of the segments from the clamping rings, which are of the same class of construction as those in commutators on standard makes of power motors, being accurately machined to gauge by special tools.

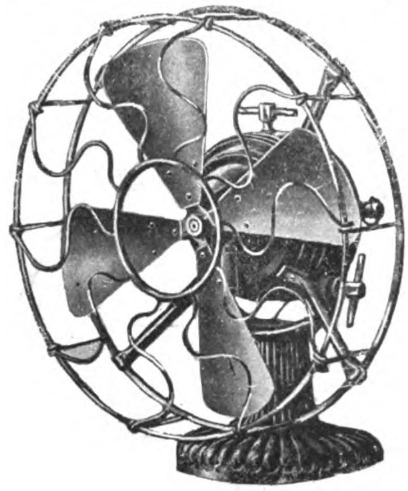


FIG. 75.—PEERLESS DESK MOTOR.

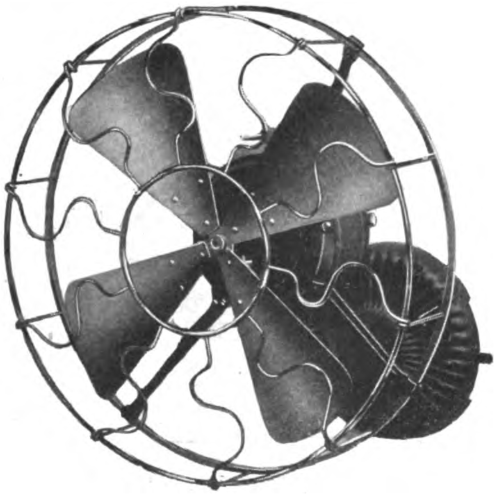


FIG. 76.—PEERLESS BRACKET MOTOR.

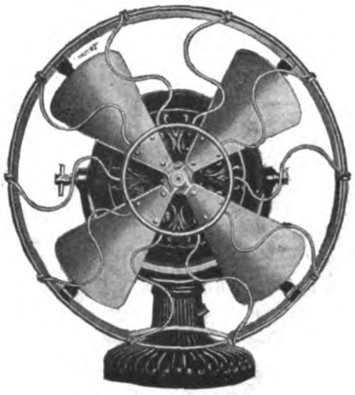


FIG. 77.—PEERLESS ALTERNATING-CURRENT MOTOR.

The 110-volt and 220-volt motors have speed regulating rheostats, the resistance coils of which are of German silver wire, of ample cross section to prevent overheating, wound on porcelain spools, with the various layers separated by sheet asbestos. All parts are insulated after completion with an insulating compound guaranteed to stand a temperature of 500 degrees. The various switch contacts and main terminals are mounted on a porcelain disc, as usual in this class of machine. The desk fans have three speeds.

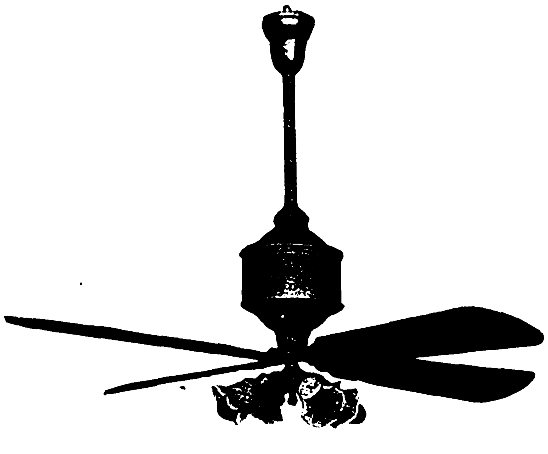


FIG. 78.—PEERLESS CEILING MOTOR.

The Peerless Electric Company has also brought out an alternating-current induction fan motor which has some new features worthy of note. This machine is shown by Fig. 77. The starting switch, which is located in the back of the casing, is so constructed that the movement of turning the current on also imparts an impetus to the rotor and fan, the machine not being of the self-starting type. The rotor is of the squirrel-cage pattern, with a shaft of drawn steel. The bearing of the shaft is long and is composed of a seamless drawn tube of phosphor bronze forced into position in the fan motor case, being reamed to accurate size after it is placed in position, thereby avoiding the liability of a poor fit on the motor shaft. The base of the starting device and switch is made of vulcanized rubber, and the contact blades and points are of phosphor bronze. The mounting is of the swivel and trunnion type. The motors are made with three speeds and are of two sizes: 12-in. and 16-in. They are wound for any voltage and frequency up to 250 volts and 140 cycles.

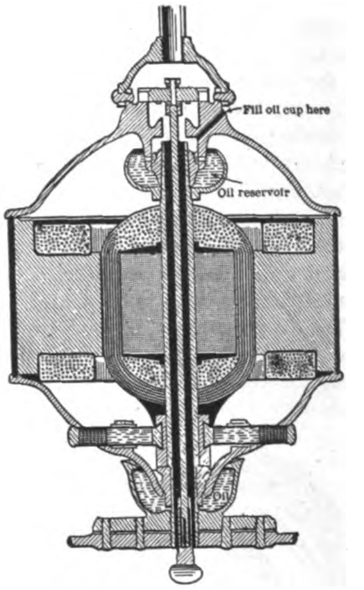


FIG. 79.—CROSS-SECTION OF PEERLESS CEILING MOTOR.

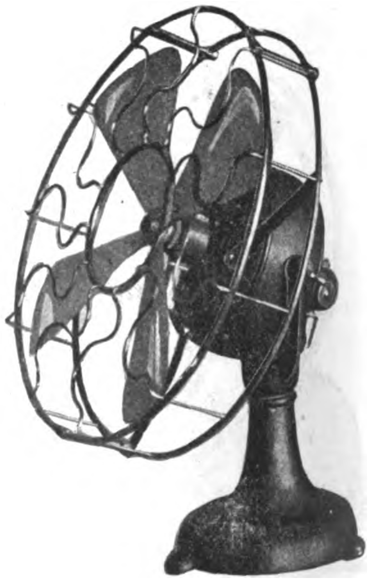


FIG. 80.—DAYTON DESK MOTOR.

Fig. 78 illustrates the Peerless Type H-2 ceiling fan, which is built for all of the usual direct-current voltages, and Fig. 79 is a cross-section of this machine. The motor is bipolar, with form-wound coils throughout, and the insulation and other features are the same as in the desk motor. The lubrication of the bearings is effected by means of two oil baths in which the bearings are submerged. The switch spindle passes up through a hollow armature shaft to the switch at the top of the machine. The bearings are of high-grade gun metal and the bushings are self-aligning. The brushes and brush-holders are of the carbon pencil and cartridge type, which is now so universally used, and are accessible without removing any of the casing. The sweep of the blades is 60 ins., and the normal speed with four blades is 200 r.p.m.; with two blades the speed is increased to 220 r.p.m. The power consumption ranges from 110 to 115 watts, according to the voltage. The 500-volt fans run at one speed only, but those for lower voltages are provided with a two-speed rheostat in conjunction with the switch.

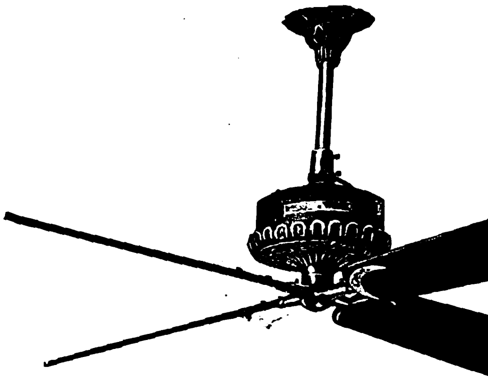


FIG. 81.—DAYTON CEILING FAN.

Fig. 80 illustrates the direct-current desk fan motor built by the Dayton Fan & Motor Company. This machine is bipolar and equipped with the usual form of slot-wound drum armature, cartridge and pencil brush-holders and brushes, under-feed self-oiling bearings, and three-speed rheostat. The machine is built in three styles of mounting: the swivel and trunnion pedestal mounting, shown in the engraving, the same style of mounting in bracket form, and a rigid pedestal mounting. The motor is wound for 110, 220 or 500 volts. The speeds are 1800, 1300 and 800 r.p.m., and the power consumption for the 12-in. fan is 44 watts at full speed. The construction is very similar to that of the Dayton Junior ceiling fan motor, described farther along in this article.

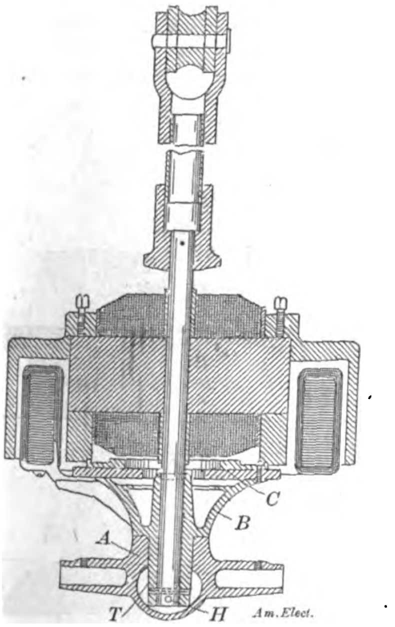


FIG. 82.—CROSS-SECTION OF DAYTON CEILING FAN.

Fig. 81 illustrates the Dayton Fan & Motor Company's standard ceiling fan for 500 volts, and Fig. 82 is a cross-section through the motor of this machine. It will be evident from an inspection of the latter engraving that the field magnet is bipolar and has channeled pole-pieces which embrace three sides of the armature cross-section. The armature winding is necessarily of the Gramme ring type, and the arrangement of the air-gap obviously results in a very low magnetic reluctance in this part of the circuit. The field-magnet coil is divided into two sections, in order to leave the center of the core free for the passage of the armature spindle. The armature is secured by means of the screws directly to the ornamental casing, *B*, which closes the motor in on the under side, and this casing also carries the commutator, *C*, which is of the disc type. The casing, *A*, with which the fan-blade sockets are integral, is screwed onto a hub at the bottom of the casing, and contains a large cup for the retention of the oil that trickles through the bearing. Oil is supplied to this bearing from the reservoir located immediately beneath the commutator.

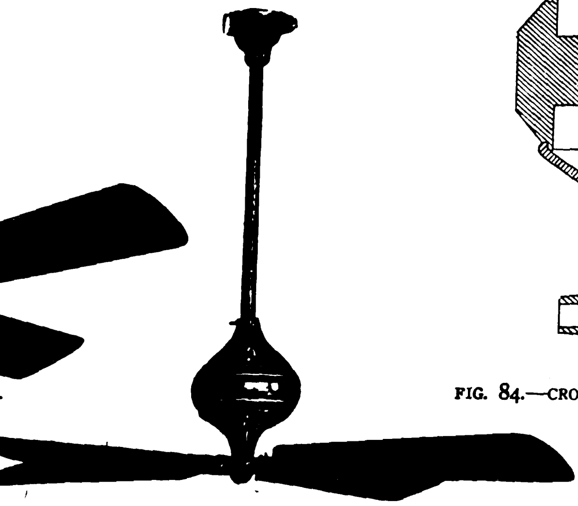


FIG. 83.—DAYTON "JUNIOR" CEILING FAN.

There is, properly speaking, no armature shaft, the casing, *B*, revolving about the stationary spindle, *H*, which is held in the socket by means of set screws. The Dayton standard fan is supplied ordinarily with four blades for all circuits except 500 volts, and runs at 215 r.p.m. The 500-volt fan is provided with two blades and runs at 210 r.p.m.

Fig. 83 illustrates the Dayton "Junior" ceiling fan motor, and Fig. 84 is a cross-section of the motor, in which the principal features of the construction are obvious. In this machine the usual form of armature shaft is employed. The case is stationary, being mounted solidly on the field-magnet frame. The lower bearing is lubricated from the reservoir in that part of the casing marked *B*, the oil being caught in the cup formed in the upper part of the fan-blade hub; the upper bearing is oiled from the reservoir, *J*, the oil that trickles through being caught in the cup, *I*, mounted on the armature shaft. The commutator of this machine is of the usual type, and the brush-holders of the cartridge type, provided with adjusting screws. The Dayton Junior fan is usually provided with four blades, and runs at 225 r.p.m.

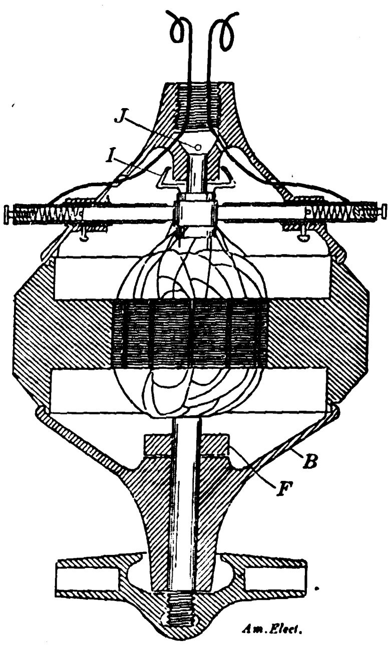


FIG. 84.—CROSS-SECTION OF DAYTON "JUNIOR" CEILING FAN.

Fig. 85 illustrates the Hurricane direct-current fan motor, built by the Eck Dynamo & Motor Works, Belleville, N. J. Fig. 86 gives a cross-sectional view through one of these machines provided with a rigid mounting, from which it will be clear that the armature and field coils are inserted through openings on opposite sides of the spherical casting, and the bearings are contained in the end caps, which close these openings. The field magnet shell and poles are cast in a single piece, as the engravings indicate, and the

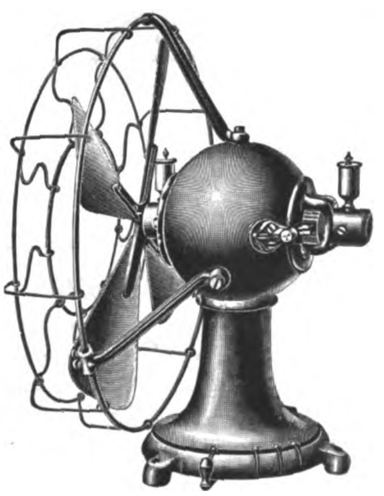


FIG. 85.—HURRICANE MOTOR.

magnet coils are form-wound and taped. The armature is of the toothed-core, drum-wound type, and the commutator is of the usual mica-insulated construction. The brush-holders differ from all others of this class. The brushes are flat carbons fed in slots by means of lateral fingers on spring-actuated plunger pins. These pins may be turned so as to release the brushes and allow them to be withdrawn without disturbing any connections, or displacing any parts of the structure. The holders are both mounted on one heavy fibre plate screwed to the motor shell. The method of lubricating the bearings is clearly shown in Fig. 86. The Hurricane motor is built also with an adjustable ball-and-socket joint between the body of the motor and the pedestal, by means of which the machine can be set at any desired angle. As shown in the engraving, this motor is provided with a speed regulating switch and rheostat, the latter being enclosed in the pedestal. The motor is built for 115-volt and 230-volt circuits, and with 12-in. and 16-in. blades. The speeds of the 12-in. fan are 900, 1400 and 1800 r.p.m., and the speeds of the 16-in. fan are 800, 1200 and 1600 r.p.m.

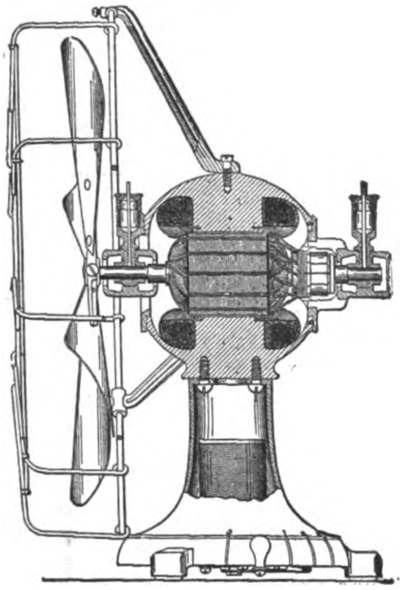


FIG. 86.—SECTIONAL VIEW OF HURRICANE DESK MOTOR.

The Eck Dynamo & Motor Works has brought out this year an oscillating fan motor, which, however, was not ready for description when this article was prepared.

Another spherical fan motor is that built by the Colonial Electric Company, Ravenna, Ohio, and illustrated by Figs. 87 and 88. Fig. 87 shows the swivel and trunnion desk machine with a 12-in. fan, and Fig. 88 shows the bracket mounting of the same machine in the 16-in. size. The Colonial motor is bipolar, with shell and magnet poles cast integral. The magnet coils are form-wound, taped, varnished and baked. The armature is slotted and drum wound. The slots are insulated with oiled linen and the coils are machine-wound directly into the slots. The machines are provided with the usual form of speed-regulating switch and rheostat mounted in the base. The normal running speed of the 12-in. fan is 1650 r.p.m., and the power consumption is 55 watts. The 16-in. fans run at 1350 r.p.m., and the power consumption is 77 watts. The bearings are of phosphor bronze, self-aligning, and provided with wick-feed lubrication. These fans are also built with rigid mounting.

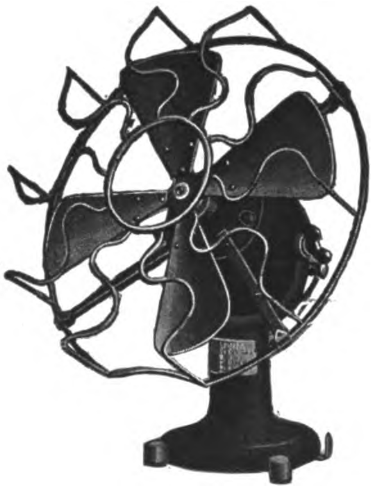


FIG. 87.—COLONIAL MOTOR.

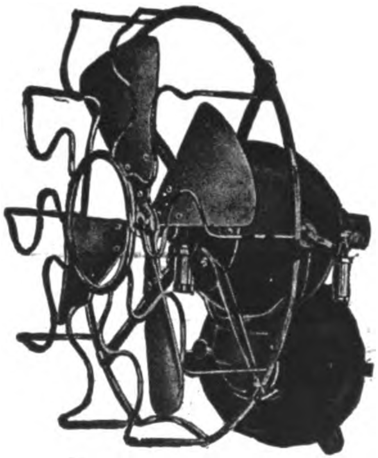


FIG. 88.—COLONIAL BRACKET MOTOR.

The Colonial ceiling fan is illustrated by Fig. 89, which shows the Type R machine. The brush-holders and brushes are of the cartridge and carbon-pencil type. The bearings are of phosphor bronze, self-oiling and self-aligning, and of such construction that the working parts are constantly immersed in oil. The sweep is 60 ins., and the speeds are 110 and 200 r.p.m. with four blades, or 130 and 220 r.p.m. with two blades; a two-blade switch being provided with each Type R fan. These machines are wound for 110, 170, 220, 250 and 500 volts, and the current required at these voltages is 1 ampere, 0.7 ampere, 0.55 ampere, 0.45 ampere and 0.23 ampere.

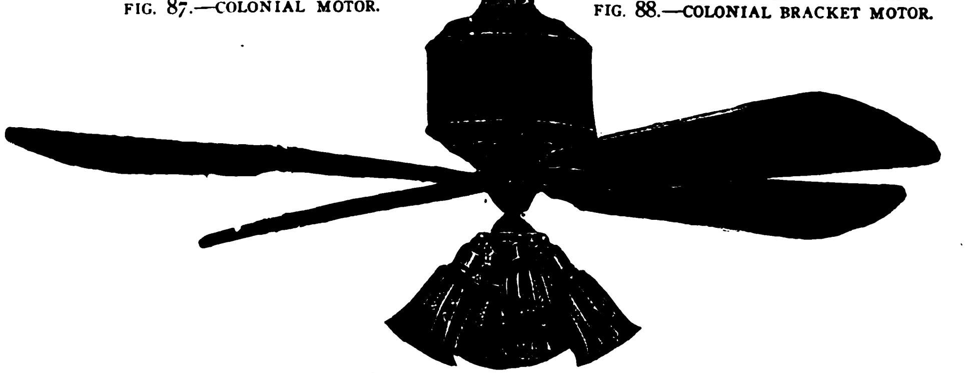


FIG. 89.—COLONIAL CEILING MOTOR.

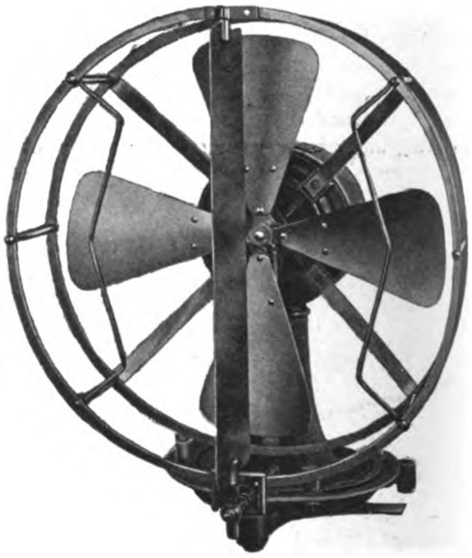


FIG. 90.—COMFORT OSCILLATING FAN.

Figs. 90 and 91 illustrate the Comfort oscillating desk fan motor built by the Shedd Electric & Manufacturing Company. This machine was new last year and a number of improvements have been embodied in it this year. The motor oscillates slowly from side to side around the vertical axis, the oscillation being caused by a vane pivoted in the fan guard immediately in front of the center of the fan. This vane is turned first one way and then the other by a finger which projects from its lower end horizontally toward the motor pedestal and impinges against a stop on the base of the pedestal at each end of the travel. Last year's fan was provided with three of these

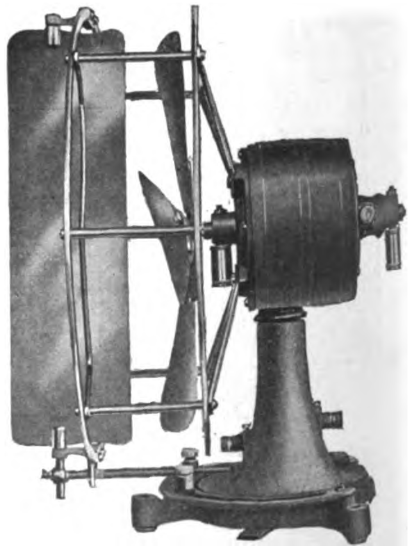


FIG. 91.—COMFORT OSCILLATING FAN.

vanes, but the builders have found a single vane to accomplish the desired result, and of course there is a slight increase in efficiency by the elimination of the other two vanes. In the original machines electrical connection was provided between the motor and the stationary pedestal in the shape of a flexible cord. This has been discarded this year and small collector rings and brushes have been substituted. Another improvement in the fan consists in balancing the motor accurately on the ball-bearing upon which it oscillates, so that oscillation will be obtained even with the machine tilted considerably either forward or backward. The motor itself is of the usual circular enclosed type of ordinary construction. The rear end-cap carries cartridge brush-holders in which carbon pencils are fed to the commutator by means of helical springs. The bearings are lubricated by automatic wick-feed oil cups. On account of the patent situation, the company does not build an alternating-current fan motor, but it does manufacture an oscillating base upon which any ordinary fan motor may be mounted and thereby converted into an oscillating machine.

The Coleman Manufacturing Company, New York, has brought out this year a deflecting arrangement consisting of a fan guard to which are pivoted four vanes, these vanes being oscillated back and forth by a mechanism driven from the spindle of the motor. Fig. 92 illustrates one of these fan guards applied to a Diehl motor, and Fig. 93 is an explanatory outline engraving from which the operation of the deflector vanes may be ascertained by inspection. The driving mechanism consists of a very small worm gear mounted in the top of the fan guard and driven by a tiny round belt from the front end of the motor shaft. The area over which the air is distributed may be regulated by adjusting the stroke of the pitman which connects the worm-wheel with one of the pivoted vanes. This device obviously may be attached to any fan motor.

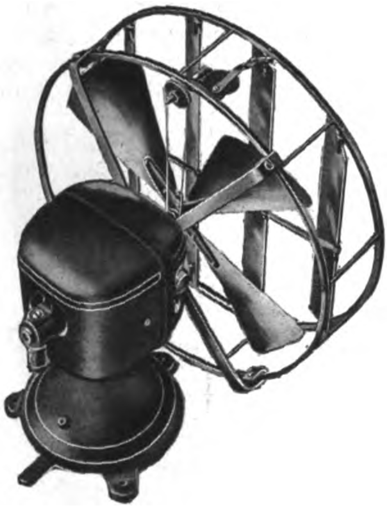


FIG. 92.—COLEMAN DEFLECTOR.

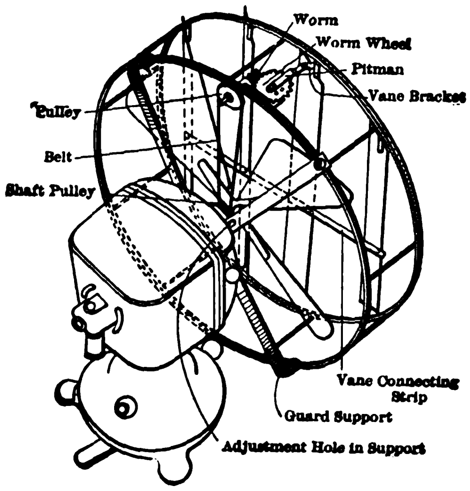


FIG. 93.—COLEMAN DEFLECTOR DETAILS.

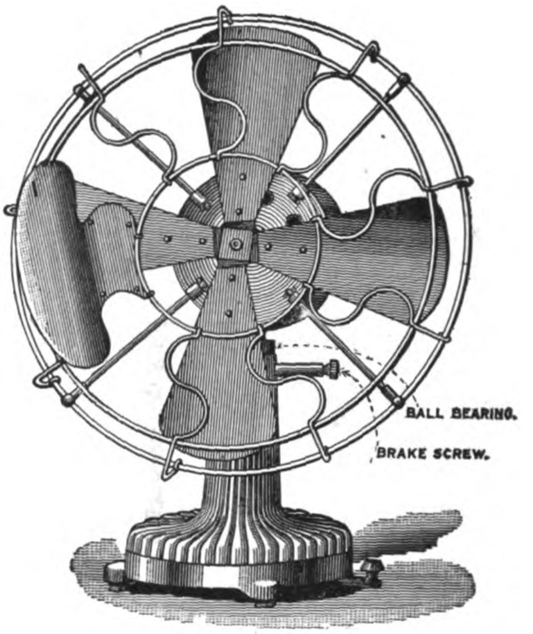

BALL BEARING.
BRAKE SCREW.

FIG. 94.—TOWLE REVOLVING MOTOR.

Fig. 94 illustrates a revolving desk fan motor brought out this year by the George C. Towle Manufacturing Company. The motor is mounted upon a ball-bearing at the upper end of the pedestal and is caused to rotate about its axis by an air deflector attached to the front of the fan guard. The shaft of the vertical bearing extends downward to the lower part of the pedestal cavity and to its lower end are attached two small insulated collector rings; brushes mounted on a porcelain base-plate are in contact with the rings, and this arrangement serves to convey current from the stationary terminals on the pedestal to the rotating motor. The speed at which the machine revolves is adjustable by means of a friction brake, the pressure of which can be varied by turning a screw in the base.

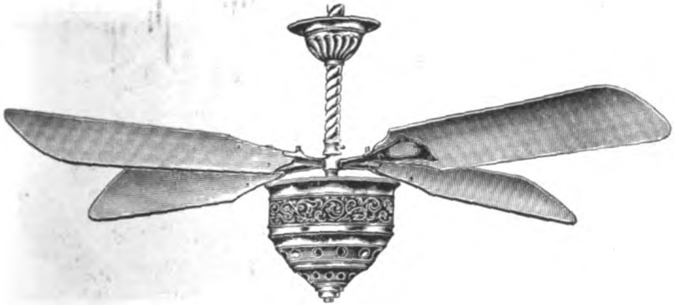


FIG. 96.—TOWLE CEILING MOTOR.

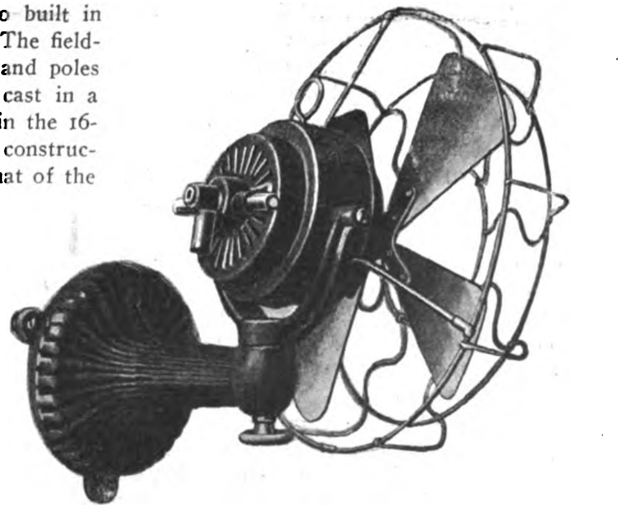


FIG. 95.—TOWLE BRACKET MOTOR.

Fig. 95 illustrates the standard Towle bracket fan motor, which is also built in pedestal form for desk service. The field-magnet is bipolar and the yoke and poles of the 12-inch size are of iron, cast in a single piece. The material used in the 16-inch fan motor is cast steel; the construction is otherwise identical with that of the 12-inch machine. The field-magnet coils are form-wound and the armature coils are wound directly into the slots. The brush-holders and brushes are of the cartridge and pencil type mounted in the rear enclosing cap of the motor frame, as clearly shown in Fig. 95. The 110-volt machines are wound with cotton-covered wire, and the 220 and 250-volt machines are wound with silk-covered wire. A rheostat and switch are mounted in the base of the machine and give three speeds, which are 1000, 1600 and 2000 r.p.m. for the 12-inch fans, and 600, 1000 and 1650 r.p.m. for the 16-inch fans. The motors are wound for 110, 170, 220 and 250 volts. The Towle ceiling fan motor, shown by Fig. 96, is of substantially the same construction as the desk and bracket types of machine, so far as the motor itself is concerned, with the exception that the field-magnets have four poles and the armature coils are form-wound and insulated before being placed in the core slots. These machines are wound for the three standard direct-current voltages and also for 170 and 250 volts for series grouping; the speed is 160 r.p.m. When desired, the ceiling fan motor, with the exception of the 500-volt machine, is provided with a two-speed rheostat and switch.

The construction of the ceiling fan motor of the Sterling Electric Motor Company (Dayton, Ohio) is shown by Fig. 97. The motor is of conventional design, having the field-magnet, yoke ring and poles cast in a single piece and provided with form-wound coils, taped and varnished. The armature is drum-wound, and the coils are wound in a former, and individually taped and varnished. A single bearing of unusual length is employed, and this is lubricated from the oil reservoir shown in the engraving. The speed-regulating rheostat is of fireproof construction, and is located above the motor, so that it has full ventilation, and the heat generated in it cannot affect the bearings or windings of the machine. The regulating switch is also located at the top of the motor and operated by means of a spindle extending through the hollow armature shaft, as in the cases previously cited, and terminating in a key below the fan-blade hub. The brush-holders are of the usual cartridge type, with radially-fed brushes which can be removed and replaced without disturbing any other part of the machine. Every part of the machine is made to gauge by automatic machinery, so that all repair parts are strictly interchangeable with the originals, and the cost of manufacture is reduced without sacrificing the machine. The motor is wound for the usual direct-current voltages.

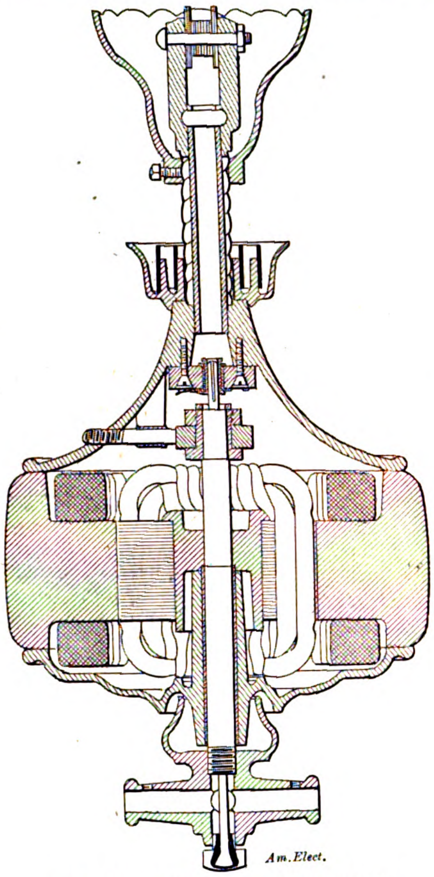


FIG. 97.—STERLING CEILING MOTOR.

Fig. 98 shows the Tuerk ceiling fan motor built by the Hunter Fan & Motor Company. The motor is of the squirrel cage induction motor type, with an ingenious speed-reducing arrangement of leather-faced friction wheels between the motor shaft and the fan shaft. The blades have 60 inches sweep and their speed is 175 r. p. m. The motor requires 100 watts, and is wound for all standard alternating-current voltages, and for both high and low frequencies.

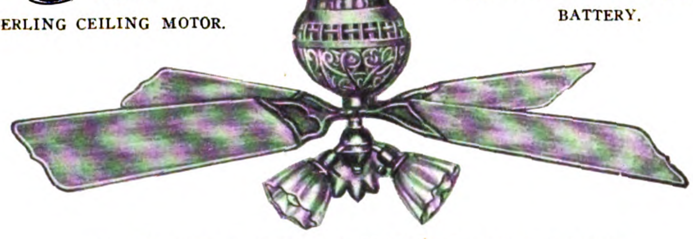


FIG. 98.—TUERK ALTERNATING-CURRENT CEILING MOTOR.

Fig. 99 illustrates the battery motor outfit of the Edison Manufacturing Company, which has become so well known as to require almost no description. This machine is bipolar, with a field-magnet of the Van Depoele type, the magnet being of cast-iron in a single piece. The armature core is laminated and slotted around the periphery; the winding is of the Gramme ring, and the motor will run a 9-inch fan 150 hours on one charge of the battery. The battery is of the well-known Edison-Lalande type. Fig. 100 shows a smaller size of battery motor built by the Edison Company. The field-magnet of this machine is also bipolar, but of the enclosed type, and the magnet and yoke ring are cast in a single piece. The armature is of the polar type, having three polar projections, and the core is laminated. The motor drives a 7-inch fan and will run 150 hours on one charge of the battery. The latter is of the same type as the battery used with the 9-inch machine, the only difference being in the number of cells required.

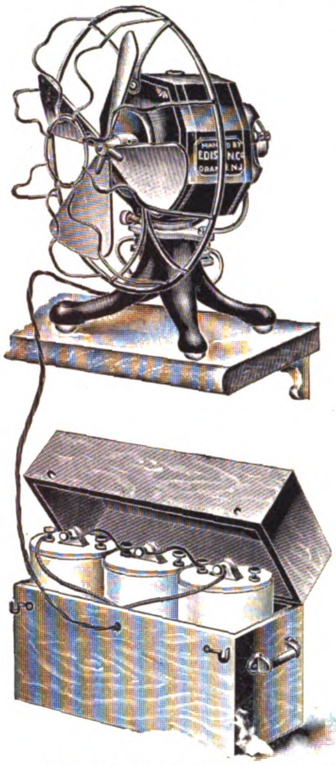


FIG. 100.—EDISON MOTOR AND BATTERY.

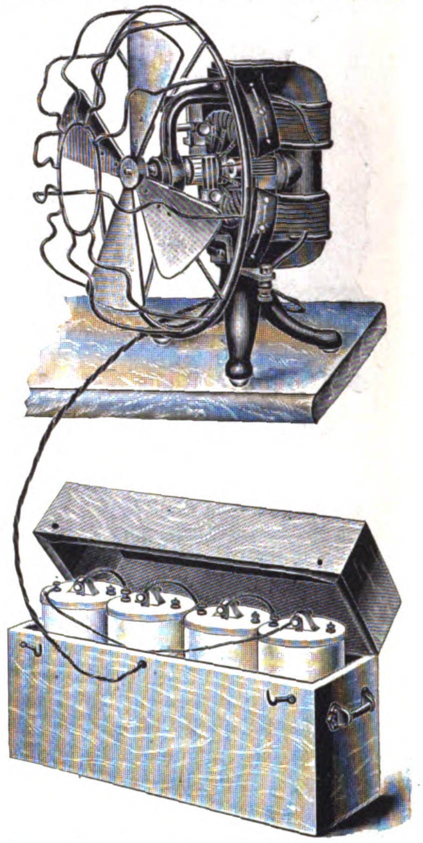


FIG. 99.—EDISON BATTERY MOTOR OUTFIT.

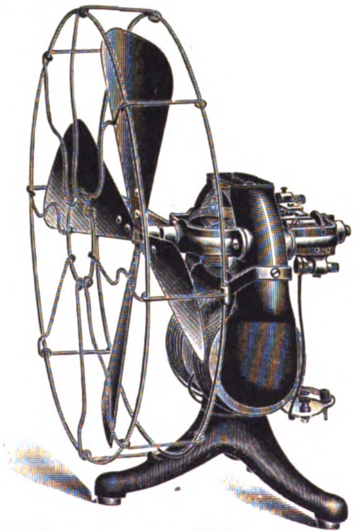


FIG. 101.—KNAPP TYPE "F" BATTERY MOTOR.

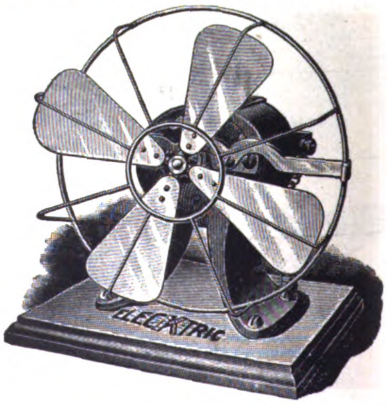


FIG. 102.—KNAPP TYPE "C" BATTERY MOTOR.

The Knapp Electric & Novelty Company has brought out a new battery fan motor this year which is illustrated by Fig. 101, and designated Type F. This is a bipolar machine with a cast-iron field-magnet; the field winding is divided into two coils in order to provide for the attachment of the magnet to the pedestal. The armature core is laminated and is of the slotted drum type with six slots, and consequently six teeth. This little machine is wound for any e.m.f. from 2 to 10 volts and the current required is 1½ to 2 amperes at 2 to 4 volts, 1 ampere at 8 volts, and 1½ amperes at 10 volts. The fan is 10 inches in diameter and the weight of the complete machine is 7 pounds. The Knapp

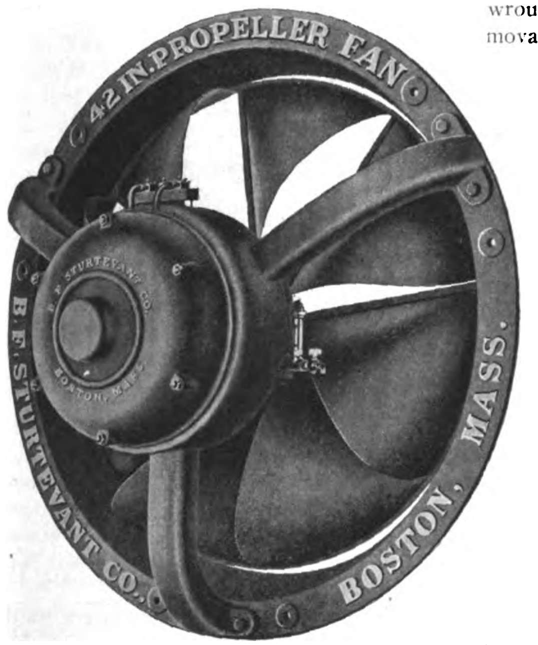


FIG. 103.—STURTEVANT BIPOLAR VENTILATING MOTOR.

Type C battery fan motor is illustrated by Fig. 102; this machine has been on the market for several years. The field-magnet is of the single coil type and the armature core is of the slotted drum type but made of cast-iron. There are six slots and the winding is similar to that of the type F machine. The fan is 8 inches in diameter and the machine is wound for either 2 volts or 5 volts.

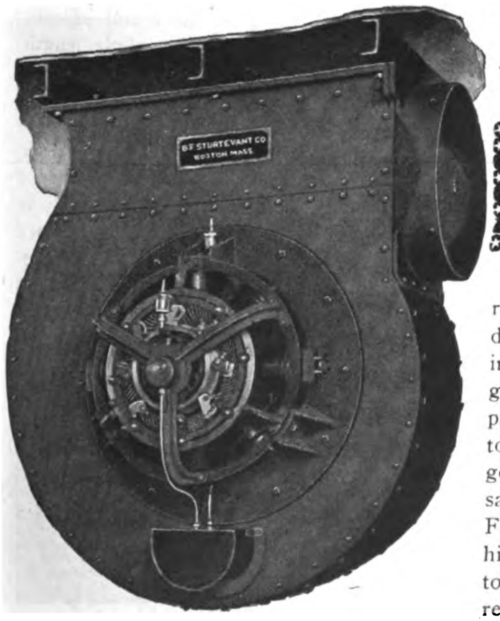


FIG. 105.—STURTEVANT EIGHT-POLE MOTOR.

Figs 103, 104 and 105 illustrate representative types of ventilating fan motors built by the B. F. Sturtevant Company, which uses different types of motor for different classes of services. Fig. 103 illustrates the enclosed bipolar machine used for driving fans of the propeller type; Fig. 104 shows a four-pole enclosed machine direct-connected to a steel plate fan; and Fig. 105 shows an eight-pole open machine for driving plate fans. The field-magnet yoke of the bipolar machine is of cast steel and the magnet poles are of either steel or wrought iron bolted in. The machines having steel magnet poles are provided with polar extensions cast integral with the magnet cores, and those having wrought iron cores are provided with removable steel shoes.

The magnet coils in all cases are form-wound, of double cotton-covered magnet wire, and baked for two hours before being covered with additional insulation. The coils are then given two layers of heavy cotton tape, saturated with an insulating compound and baked five hours at a temperature of 150 degrees Fahr. After this they are covered with two layers of oiled tape and two layers of finishing tape, the outer coating of tape being painted with a heavy coat of quick-drying black varnish which is said to be oil, water and acid proof. When the coils are placed on the magnet cores, a break-down test of 2500 volts is applied for one minute. The armatures are all of the toothed drum-wound type and the armature coils are form-wound and wrapped with two layers of heavy cotton tape, after which they are saturated with insulating compound and baked. The core slots are insulated with troughs from 10 to 20 mils thick.

On motors of ⅜ horse-power (driving a 30-inch propeller fan) and under, the brushes are round carbon pencils fed in cartridge-type holders by helical springs. In larger machines ordinary rectangular carbon brushes are used, fed in holders of the box type by means of flat phosphor bronze springs.

The journals are, of course, self-oiling in all cases. The bearings of the enclosed bipolar machine shown by Fig. 103 are not mounted in the enclosing heads or caps, but are located in yokes fastened to the field-magnet structure independently of the enclosing caps. These caps may therefore be removed, giving access to the interior of the machine without changing its running condition. This is not true of the four-pole motor shown by Fig. 104, the journal boxes of which are located in the curved head or cap. In this case, access to the interior of the machine is provided by leaving an opening in the upper part of the end cap which is normally closed by means of a hinged cover plate, shown thrown back in the engraving. The journal brackets of the open types of machine are clearly shown by Fig. 105 and require no explanation.

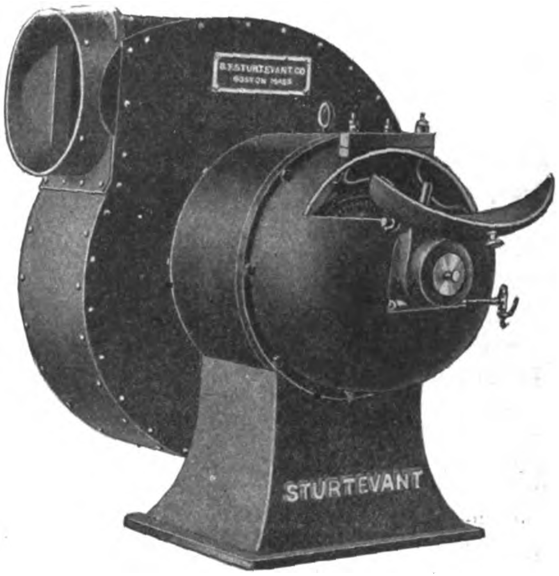


FIG. 104.—STURTEVANT ENCLOSED STEEL PLATE MOTOR.

Abstracts from Foreign Contemporaries

The Governing of Alternators.—At a recent meeting of the Société Internationale des Electriciens M. de Marchena read an interesting paper on the governing of engines coupled to alternators running in parallel. The parallel running of alternators is greatly influenced by the action of the governor, a fact which, M. de Marchena says, has been generally overlooked by other French writers on the subject, who have, in his opinion, attached too much importance to the question of irregularity during one revolution of the fly-wheel. According to M. de Marchena, the frequency of pulsation of the power of the engine is too high compared with the frequency of the oscillations proper to the alternator itself to permit angles of displacement between alternators to attain a dangerous value. On the other hand, the irregularities of power arising from instability of the governor are liable to produce very considerable displacements, resulting in running out of phase or breaking down of alternators. Examining the working conditions of the governor when the alternator is connected to the network, the author shows that the oscillations and greatly variable frequencies produced by irregularities of the motive power or by quick fluctuations of load give rise to oscillations of the governor, the amplitude of which depend upon the natural oscillations of the governor as well as upon its damping. He examines in each case the conditions of resonance which may be obtained and the consequences. In order to obviate these inconveniences it has hitherto been the practice to employ a relatively strong damping; but M. de Marchena considers that a more rational solution of the difficulty is to suppress the cause of these oscillations entirely by making the governor independent of the influence of the oscillations of the alternator. He therefore proposes to drive the governor, not by the engine itself, but by an induction motor connected to the network. This motor, not being dependent on individual oscillations of the machine, will not change its speed, and will only act on the governor when the frequency of the network is modified. The writer mentions a test made with this system in a large water-power generating station in the Nice district, including turbines of 1,000 horsepower each, in which special arrangements were employed for avoiding troubles liable to result from accidental stopping of the motor. The results are stated to have been entirely satisfactory, the oscillations which were experienced at first having entirely disappeared. It is anticipated that this system is likely to be efficient in general use, and the author expects it to be used shortly for facilitating parallel running of stations separated by long distances.

Application of Pupin's System to Telephone Circuits.—Recent experiments with the Pupin system prove that by the insertion of inductance coils in telephone circuits in the manner described by Prof. Pupin, the great advantages theoretically claimed are obtained in actual practice. Experiments were performed by F. Dolezalek and E. Ebeling on the Berlin-Potsdam cable and also on an overhead line between Berlin and Magdeburg, Germany. The cable between Berlin and Potsdam is about 32.5 km. (20.2 miles) long, and was laid by Siemens & Halske a few years ago for the German postal authorities to relieve the pole lines connecting the two places, and for intermediate local traffic. The cable contains 28 pairs of conductors of 1 mm. copper wire, with air space paper insulation, of the usual Siemens & Halske construction. This cable, with the exception of the portion in Berlin itself, is of U. G. type, lead-covered, armored and compounded; the portion in Berlin, being drawn into tubes, is without the compounded covering. Of these pairs 14 were left in their original condition, a most convenient arrangement, as it was thus possible by direct comparison between the equipped and unequipped lines to obtain a clear idea of the improvement gained. It was, of course, necessary in order to prevent disturbance of the cable, that the inductance coils should be introduced at the junction boxes already existing which connected the individual manufacturing lengths. The distance between the coils had, therefore, to be limited to certain definite figures. Inserting them at every second box, a distance of about 1,300 metres between the coils was secured. Each coil introduced a resistance of about 4.1 ohms in each wire of the circuit, and an inductance of about 0.062 henry. As the resistance of the cable conductor, with coils included, amounted to 23.5 ohms per kilometre, while the wire-to-wire capacity was about .037 mfd. per km., the value of the attenuation constant became 0.0106.

The self-induction of the simple metallic circuit measured with an alternating current of 900 periods per second, gave 0.0003 henry per km. The attenuation constant for the simple circuit was therefore 0.06 (at 900 periods). Consequently by insertion of the coils the inductance was increased 200-fold, and the attenuation constant reduced to one-sixth.

As a result of this large reduction in the attenuation a considerable improvement in audition was to be expected, and did, in fact, result. Comparing an equipped circuit with one of the simple circuits between Berlin and Potsdam, the length of which as mentioned was 32.5 km., an enormous difference was noticed in the loudness of the tones. While with an unequipped line the distance from the receiver for good audition could not exceed half a metre, with the equipped line audition was perfectly distinct at 10 metres distance, *i. e.*, at the opposite end of the room. This experiment was conducted with the ordinary type of Siemens subscribers' instruments, the transmitter being actuated by two Hellesen cells. As there were at disposal 14 equipped and unequipped circuits, it was possible to experiment on longer circuits by joining single lengths in series.

Joining three lengths in series afforded a circuit of about 97.5 km., and comparing the equipped and simple circuits, the difference between the two was more striking than in the first case, when the speaking was carried on over a length of only 32.5 km. While it was possible with the equipped line to hear clearly at a good distance from the receiver, with the unloaded line the limit of audition had been reached, confirming with exactitude the results theoretically arrived at.

With five lengths joined in series, or a circuit of about 162.5 km. on the unloaded line, it was only a very accustomed ear that could recognize the slightest movement in the telephone diaphragm, while with the loaded line a very distinct articulation was produced. By direct comparison of the loaded circuit of 162.5 km. with the unloaded circuit of 32.5 km. the loudness of tone was found to be approximately the same. Over 13 lengths in series, or about 422.5 km., reception was still possible, but the tones were very weak.

Comparing an overhead circuit between Berlin and Potsdam of 2 mm. bronze wire with a loaded circuit in the U. G. cable of the same length, the loudness of speech was approximately the same. The results depended a little on the state of the atmosphere. In good weather the loudness on the overhead wire was a very little greater than on the cable, while in bad weather the converse obtained, the cable circuit being a little louder than the overhead.

The result of this comparison is most noteworthy, inasmuch as it shows that by application of Pupin's system, a cable with a conductor of 1 mm. diameter can be rendered equivalent in speaking capacity to an ordinary unequipped overhead wire of 2 mm. diameter, or four times the section. Theoretical calculations show that this result was to be expected, but still it presents a striking confirmation of the correctness of Prof. Pupin's views. The arrangement of the inductance coils was very simple. Each set of 14 coils of annular construction was inserted in an iron box, and the necessary connections to the cable made by means of a special connection box, both being subsequently filled up with compound. Fig. 1, taken from the *Electrotechnischer Anzeiger,* gives a view of such a box with the connections complete.

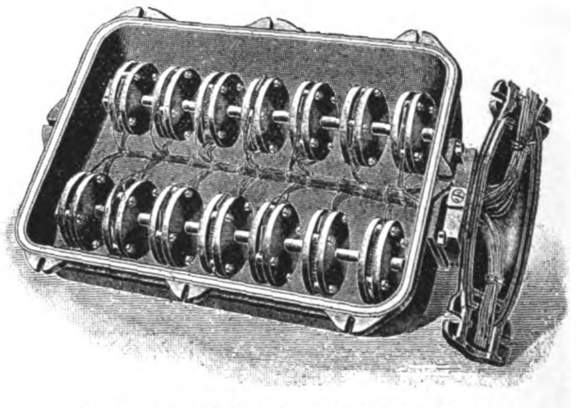


FIG. 1.—ARRANGEMENT OF INDUCTANCE COILS.

After this satisfactory conclusion of the cable experiment, the German postal authorities placed at the disposal of Siemens & Halske for equipment a bronze overhead line of 2 mm. diameter, about 150 km. long, connecting the cities of Berlin and Magdeburg, and serving for the inter-communication of six intermediate stations connected along the line; this could be compared with a line of 3-mm. bronze wire about 180 km. in length, serving for direct communication alone between the same places.

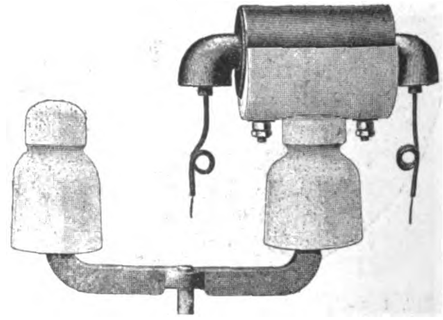


FIG. 2.—DOUBLE INSULATOR.

Before the loading of the 2-mm. circuit, the communication over the whole length was naturally inferior to that on the 3-mm. circuit. The 2-mm. line was now equipped with Pupin coils, a condition being imposed that no interference with traffic should be caused, the compliance with which presented no difficulty. At every 4 km. distance was inserted a coil of about 6 ohms resistance and 0.08 henry inductance. On the completion of the loading, the speech over this line was considerably louder than over the 3-mm. line. The installation of the coils was so arranged that at the poles where they were to be inserted double insulators were affixed, on one of which the coil had been mounted, as shown in Fig. 2, and in this manner the alteration was effected without affecting the insulation of the line. In the course of this experiment it was discovered that each such coil must be provided with a lightning protector; this could have been so arranged that at both ends of the coil the discharge would be led to earth, but as actually erected the coils were bridged by a vacuum protector.

A New Vacuum Dryer.—Cables, wires, coils, armatures and a host of electrical parts require treatment in some kind of a drying chamber, and probably no process gives such uniform results as a vacuum chamber, wherein any desired temperature can be evenly maintained and heat equally absorbed by all parts of the objects under treatment. An apparatus of this nature, designed by J. Radcliffe, is described in the London *Electrician*. It consists of a cylindrical chamber, heated by circulating steam through a series of U-shaped tubes. To the front end of the chamber is attached a steam ring and tube plate, through which the tubes are passed to the back of the chamber and back to the tube plate, in which both ends are expanded. When the apparatus is in use the articles to be dried are placed on a movable platform of form suitable to the particular purpose, and run in to the chamber, the door of which is then closed. Steam is now admitted to the ring, and circulates through the tubes, and the connection to the air-pump exhausts the chamber to the condenser. Condensation in the steam ring is provided for by a draincock leading to a steam trap, while other liquids may be recovered from the drying chamber and used over again. Should it be desired to use the apparatus as an impregnating chamber, an obvious modification of the connections will enable the conversion to be made very readily. It will be noted that there are no internal pipes or joints which would be liable to give trouble.

SOME RECENT ELECTRICAL PATENTS

Arc Light Switchboard.—In the usual form of arc light switchboard the transfer of one of several machines from one circuit to another, or the transfer of circuits from one machine to another, is commonly effected by means of plugs and sockets, the plugs having cables connecting them to the various circuits. The result of course is frequently a complicated crossing of the cables on the front of the board, entailing considerable inconvenience in making quick changes. Another form of board frequently used consists of circuit bus-bars running in one direction and dynamo bus-bars running at right-angles thereto, plugs being used to cross-connect between the two sets of bus-bars. This arrangement obviates the cable nuisance, but involves the disadvantage that additions to the number of dynamos usually compels an increase in the face area of the board in proportion to the square of the number of machines added. Figs. 1 and 2 herewith illustrate a form of plug-board which has been patented by Edward M. Hewlett, of Schenectady, N. Y., and in which both of the disadvantages just noted are avoided. Mr. Hewlett provides a series of vertical bus-bars for the dynamos and another series immediately above them for the circuits. At right angles to both of these groups are provided transfer bus-bars, which Fig. 1 shows located close against the back of the switchboard. Tubes of insulating material connect the two sets of bus-bars, and these tubes of insulating material contain sockets electrically connected to the bars, so that a plug thrust in any one of the sockets on the front of the board will connect the two bus-bars crossing each other in line with that socket. Any one of the upper vertical bus-bars may be similarly connected to the vertical bus-bar immediately below it by inserting a plug in the socket at the top of the lower bus-bar. It is necessary to insert plugs in the sockets at the upper ends of the top row of vertical bus-bars and at the bottom ends of the lower row of vertical bus-bars in order to connect these to the respective terminal blocks immediately above and below them. Fig. 2 shows plugs inserted in the proper sockets for connecting each set of bus-bars straight through, up and down the board, without using any of the transfer bus-bars, and Fig. 3 is a diagram of circuits, the crosses indicating plugged sockets. The plug, *15d*, connects the circuit terminal above it with the vertical bus-bar in the upper bank. The plug, *15b*, connects the lower end of that bus-bar to the upper end of the bus-bar below it, and the plug, *15*, connects the dynamo terminal with the lower end of its bus-bar. Each machine is obviously connected to the circuit bearing the same identification letter. Now suppose, for example, it should be desired to shut down the machine, *B*, and transfer its circuit to the machine, *A*. Plugs would then be inserted in the sockets marked *15g* and *15i*,

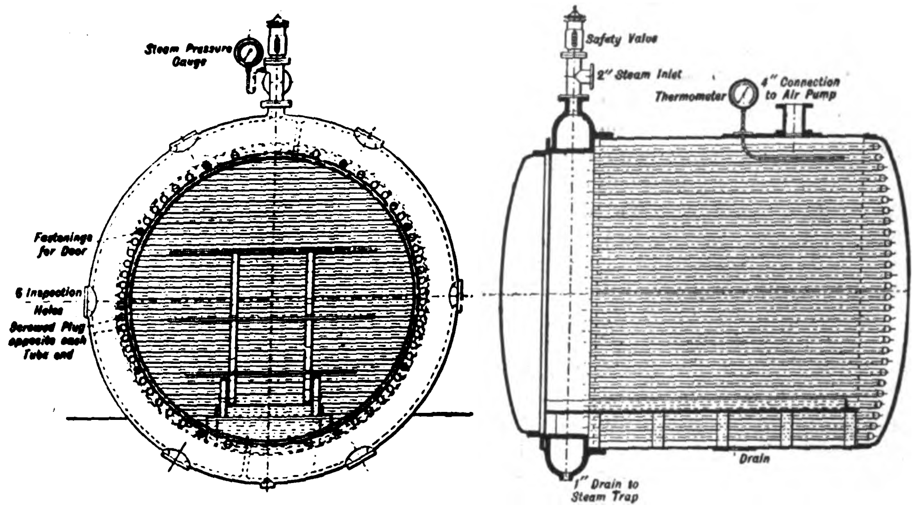


FIG. 3.—VACUUM DRYER.

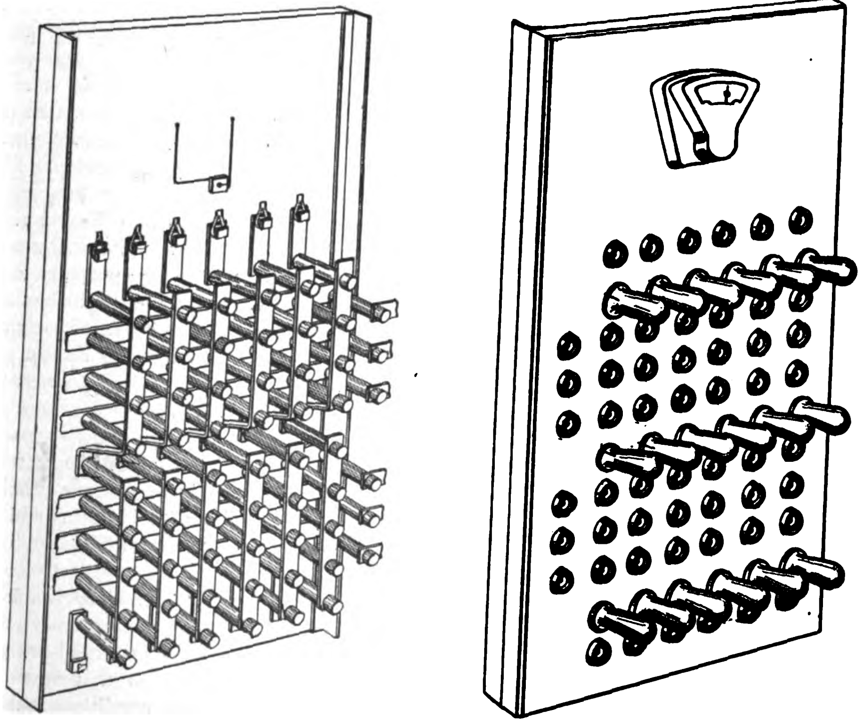


FIG. 1.—ARC LIGHT SWITCHBOARD.—FIG. 2.

thus connecting the positive and negative terminals of machines *A* and *B*, and in sockets *15h* and *15j*, which would similarly connect the incoming side of one circuit with the outgoing side of the other. Then the plugs in *15c* and *15f* would be withdrawn, leaving the two machines and their two circuits connected all in series. After this it would only be necessary to short-circuit the machine, *B*, by inserting a plug in the socket, *15k;* the plugs *15i*, *15l* and *15m* would then be withdrawn, leaving the circuits, *A'* and *B'*, connected in series and supplied by the dynamo, *A*. It is evident that the horizontal transfer bus-bars enable an almost unlimited number of combinations to be made. The sockets at the extreme top and bottom of the board are for the purpose of inserting an ammeter in any of the circuits, and also for making cross-connections by means of plugs and twin cables in emergencies when the transfer bus-bars may be in use in such fashion as to prevent their further utilization in making changes. Patent No. 717,194.

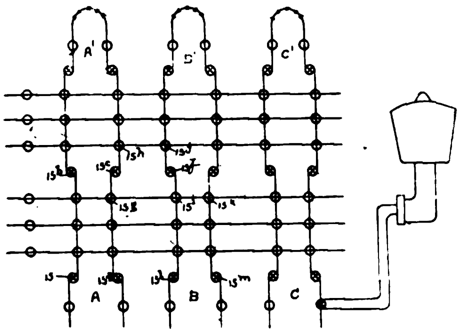
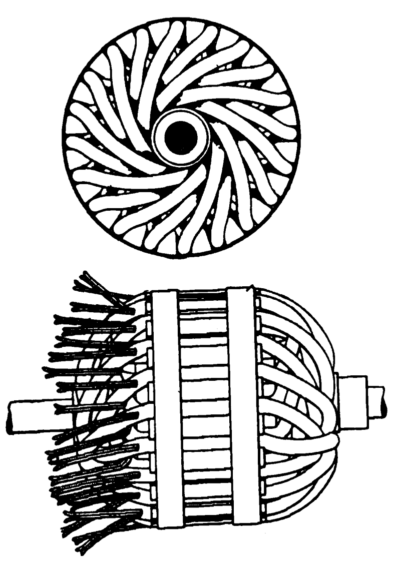


FIG. 3.—DIAGRAM OF CIRCUITS.

Drum Armature Windings.—Since the production of the now well-known Eickemeyer armature coil for bipolar dynamos, numerous forms of machine-wound coils have been devised with a view to obtaining the results which were the object of Mr. Eickemeyer, namely, to have all coils of the same length and of such shape as to allow them to be wound in formers and individually insulated before being placed on the core. One of the simplest windings of this class is that in which a coil of oval outline is employed, as illustrated by Figs. 4 to 6 inclusive. This winding has been patented by H. A. Balcome. As shown by Fig. 6, one side of every coil is placed in an armature slot before the other sides are brought into place, and then the second sides are gradually pulled into the appropriate slots on top of the coil sides already in the slots, producing the result indicated by Figs. 4 and 5. In view of the fact that substantially this same winding has been in use on multipolar machines for ten years, it appears odd that it should be patentable now. Patent No. 725,011.



FIGS. 4 AND 5.

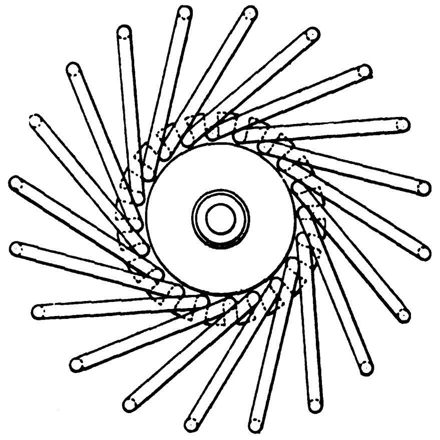


FIG. 6.

NOTES.

A Long Electric Railway Line.—A charter has been issued to the Central Missouri Electric Railroad Company for a road to extend from St. Louis to Glasgow and thence to Brookfield—a distance of 194 miles. The road is to be completed in time for the St. Louis Exposition.

Chicago Electrical Association.—At the February meeting of this flourishing organization, Mr. H. M. Brinckerhoff, general manager of the Metropolitan Westside Elevated Railway Company, Chicago, read an interesting paper on the third-rail system. Papers scheduled for March and April meetings are as follows: On March 6, a paper on "Engineering Activity in the Central West," by S. G. McMeen, of the Western Electric Company's engineering department; March 20, "Telephone Service," by S. J. Larned, general superintendent of the Chicago Telephone Company; and April 3, "Effects Produced by Grounding the Neutral on an Alternating-Current System," by G. M. Eastman, of the Chicago Edison Company's testing laboratory.

Science Abstracts is now published in two sections, namely, Section A, devoted to Physics, which embraces Light, Heat, Sound; Electricity and Magnetism; Chemical Physics and Electro-Chemistry; General Physics; Meteorology and Terrestrial Physics, and Physical Astronomy. Section B, embracing Steam Plants, Gas and Oil Engines; Automobiles; Balloons and Airships; General Electrical Engineering, including industrial electro-chemistry; Electric Generators, Motors and Transformers; Electrical Distribution, Traction and Lighting; Telegraphy and Telephony. The subscription prices will be 18 shillings, or $4.50 for each section separately, including the index, and for the two sections 30 shillings or $7.50. The American Physical Society has joined the Institution of Electrical Engineers and the Physical Society of London in the direction of the publication and has elected Prof. E. H. Hall, of Harvard University, as its representative on the publishing committee. In consequence of this arrangement, Section A will in future be received by all members of the American Physical Society. The American Institute of Electrical Engineers is also co-operating with the committee and taking special means to bring the publication to the notice of all its members, who will in future be able to obtain it at a reduced subscription rate through the secretary of the American Institute, Mr. Ralph W. Pope, at 95 Liberty Street, New York.

Municipal Ownership at Hagerstown, Md.—The Hagerstown *Morning Herald* recently gave vent to the following pathetic wail: "The deplorable condition of the city finances is a matter of extreme regret to every citizen and taxpayer. The municipal lighting plant shows a condition bordering on bankruptcy. It is difficult to imagine what has brought matters to such a pass when the recent statement of the Street Commissioners places the cost of street lighting at $56 per lamp. The balance of unpaid bills amounts to the startling sum of $3,900. The levy for street lighting was 9 cents on the $100, but at the time the levy was made Mayor Holzapfel insisted that it was insufficient to meet the needs, as a number of bills for the previous year were pigeon-holed and had to be paid out of this year's levy. He took the view that the street lights were costing considerably more than the commissioners contended. His statement placed their cost at $104 each. The trifle of taxes yet to be collected gives no hope of relief from this distressing condition and the taxpayers and property owners might just as well make up their minds to pay a decidedly higher tax rate next year. The deficit will have to be met and the rates placed sufficiently high to meet the current needs as well. As the increase will be entirely for electric lighting, the cost of the investment to the town will be no trifle. The city authorities have a grave problem to face, and it will tax their brains and ingenuity to cope with the situation. They will, it is hoped, confer and act wisely. They must find some method by which the city plant can be made less expensive, but, of course, with an eye to the well-being of the works and system, so that when the annual report is made conditions will be brighter and more encouraging." We have no detailed information as to the situation at Hagerstown, but on general principles it appears evident that the efforts of a competent electrical engineer unhampered by politics in the operation of the city plant might lighten the burdens of the taxpayers.

Annual Dinner of the American Institute of Electrical Engineers.—The annual dinner of the Institute this year was devoted to a celebration of the success of the library. It was given last month at Sherry's, and was in many respects a notable affair. The attendance was large, and among those present were several prominent men, notably Mr. Edison, Mr. Carnegie, Professor Elihu Thompson, Dr. John S. Billings, director of the New York Public Library, and Mr. Theodore L. De Vinne, the well-known bibliophile. Messrs. Edison and Carnegie were accompanied by their wives; both of whom took a lively interest in the proceedings. President Charles F. Scott delivered a strong salutatory, and Mr. Carnegie spoke most interestingly on the subject of libraries. In the course of his talk, Mr. Carnegie indulged in some reminiscences that were, if possible, more interesting than the more serious parts of his speech. Other able speeches were delivered by Dr. Billings, Mr. De Vinne, Mr. R. R. Bowker, editor of the *Publishers' Weekly*, and Dr. J. C. Bayles, technical editor of the New York *Times*.

A New Railway Association.—On February 12 the superintendents of motive power, electrical engineers and master mechanics of a number of electric railway companies organized what it was finally decided to call The American Railway Mechanical and Electrical Association, the object of which is the acquisition of experimental, statistical and practical information concerning the construction, equipment and operation of street and interurban railways. As is well known, the American Street Railway Association in its proceedings considers chiefly matters relating to general policy, traffic management and similar non-technical subjects, the association being composed almost exclusively of presidents, general managers and other officials of the business departments of railway companies. The present association, as its avowed object intimates, has been organized in order to deal with the practical engineering side of street railway work and thus supplement the work of the older association. The constitution of the new association contains the peculiar provision that the active members shall consist of railways companies or lessees, and the associate members, of the heads of mechanical or electrical departments of railway companies, only the active members having the privilege of voting. The meetings of the association will be held at the same places as those of the American Street Railway Association, and one day in advance of the meetings of that association. The officers elected for the first year are as follows:

President, Thomas Farmer, superintendent of motive power Detroit United Railway Company, Detroit, Mich.; first vice-president, E. W. Olds, superintendent rolling stock, the Milwaukee Electric Railway & Light Company; second vice-president, Alfred Green, master mechanic, Rochester (N. Y.) Railway Company; third vice-president, C. F. Baker, superintendent motive power and machinery, Boston Elevated Railway Company; secretary and treasurer, Walter Mower, Detroit United Railway Company; executive committee, W. O. Mundy, master mechanic, St. Louis Transit Company; T. J. Mullen, master mechanic, Scranton (Pa.) Railway Company; H. H. Adams, master mechanic, United Railways & Electric Company, Baltimore, Md.; D. F. Carver, chief engineer, Cleveland (Ohio) Electric Railway Company.

Electrical Equipment for the Osaka Military Arsenal, Japan.—One of the most complete and modern electric power plants recently installed in Japan is located at the Osaka Military Arsenal, where motors are used for operating the cranes and blowers for the cupolas in the new foundry just completed. The foundry is equipped with four 10-ton, one 25-ton and one 20-ton Morgan cranes; four 4-ton and six 7-ton cupolas, and four Root blowers, each driven by a Westinghouse 40-h.p. induction motor, which supply the blast for the cupolas. The boiler room of the power house is equipped with two Sulzer Cornish shell boilers, center fired, each boiler having its own feed-water heater consisting of two plain cylinders of the same length as the boilers. These heaters are mounted over the boiler shells and suspended from the angle irons supporting the brick work.

In the engine room there are two Sulzer vertical tandem-compound condensing engines with high-pressure cylinders 12.8 ins. in diameter, low pressure cylinders 18.7 ins. in diameter and a stroke of 11.8 ins., operating under a steam pressure of 118 pounds at 257 r. p. m. The low-pressure cylinders have a fixed cut-off and the high-pressure cylinders a variable cut-off. The air and circulating pumps are driven from the crank-shaft by eccentrics. Direct coupled to each engine is a Westinghouse 100-kw. 220-volt three-phase alternator, composite wound, and of the revolving armature type and standard construction. Two 11¼-kw. 125-volt multipolar exciter dynamos are driven by belts from the main engines; each exciter has sufficient capacity for the fields of both alternators. The switchboard, to which the two generators are connected in parallel, is of the Westinghouse standard construction. There are two three-phase feeders, each of No. 0000 B. & S. gauge, from the power house to a distribution panel located at a convenient point in the foundry, from which the circuits of the various cranes and blowers are supplied.

The cranes are all equipped with Westinghouse variable-speed induction motors and crane controllers. The close regulation of the motors and the excellent control of the cranes were subjects of much comment by the directors of the Arsenal. The design of the power house and foundry, together with the layout of all machines in the latter, was under the supervision of Mr. G. Kuwada, the mechanical engineer of the Arsenal. All of the electrical apparatus as well as the cranes, blowers and two cupolas were supplied by Takata & Co., who are the agents in Japan for Westinghouse apparatus.

Municipal Ownership Convention.—As we go to press, a national convention on municipal ownership and public franchises is being held in New York under the auspices of the New York Reform Club. The programme arranged by the advisory board is as follows:

Wednesday, February 25.—Address of welcome by Mayor Low, of New York, and Mr. John G. Agar, chairman; "Recent History of Municipal Ownership in the United States," by William Wirt Howe, former president American Bar Association, New Orleans, La.; Clinton Rogers Woodruff, of Philadelphia, secretary of the National Municipal League, and others; "Recent British Experience of Municipal Ownership," by Mr. Robert Donald, editor of the *Municipal Journal*, London; "Recent German Experience of Municipal Ownership," by Mr. Ed. T. Heyn, of Berlin; "Comparison of European and American Methods and Results," by Hon. Robert P. Porter, director of the Eleventh Census of the United States; "Transportation," by Charles T. Yerkes, of London and New York; address by Mayor Harrison, of Chicago on the same subject, and a general discussion; "City Owning and Leasing," by Mr. Edward M. Shepard, counsel to the Rapid Transit Commission, New York; "Massachusetts' Experience," by Mr. Louis D. Brandeis, of Boston. Thursday, February 26.—"Gas and Electric Lighting" (I, Electric Lighting,) by Mr. J. B. Cahoon, secretary and ex-president of the National Electric Light Association, and Mr. Victor Rosewater, editor Omaha *Daily Bee*; (II, Gas Lighting), by Mr. Walton Clark, general superintendent Gas Improvement Company, Philadelphia, Pa., past president American Gas Lighting Association, and Mr. Alton D. Adams, engineer, Boston, Mass.; discussion to be opened by Prof. Ed. W. Bemis, water commissioner, Cleveland, Ohio; "European Experience of Public Ownership of Telephones," by Mr. Bennett, engineer for Glasgow and other British municipal telephone systems; "Argument for Public Ownership of Telephones," by Prof. Parsons, of the Boston Law School; "The Superiority of Corporation Ownership of Telephones," by Mr. U. N. Bethell, general superintendent New York Telephone Company; "City Ownership of Water Supply," by Mr. William R. Hill, president of the American Water Works Association. Friday, February 27.—"How Should Public Service Corporations be Controlled?" by Mr. R. R. Bowker, formerly of the Edison Electric Illuminating Company, New York; "Regulation and Taxation of Public Service Corporations," by Mr. A. R. Foote, editor of *Public Policy;* discussion to be opened by Prof. John R. Commons, secretary Taxation Committee National Civic Federation; "Labor Clauses in Franchise Grants and the Labor View of Municipal Ownership," by ex-Mayor Chase, of Haverhill, Mass.; "Taxation of Franchise Values," by Mr. Frederick Howe, of Cleveland; discussion to be opened by Mr. Wheeler H. Peckham, president of City Club, New York.

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CONTENTS.

A Swiss Combined Water-power and Gas-engine Plant 113
Liquid Fuel, by H. F. Schmidt 118
Telephone Engineering, by F. J. Dommerque 120
American Meter Practice, by Lyman C. Reed 122
Electric Manufacture of Steel, by G. E. Walsh 123
Fan Motors for 1903 125
Abstracts and Foreign Contemporaries 141
Some recent Electrical Patents 143
Notes 144
Editorial 146
Design for a ½-h.p. Self-starting Single-phase Induction Motor 148
A Modern Private Branch Telephone Exchange, A. Dallam O'Brien 150
An Electric Train Indicator, E. C. Parham 154
Parallel Running of Alternators, W. T. Fernandez 155
Integrating Wattmeter Connections, Arthur B. Weeks 156
Lessons in Practical Electricity 157
Letters on Practical Subjects 158
Electrical Catechism 159
Queries and Answers 160
Automatic Telephone System 161
The New Westinghouse Gas-Engine 163
Direct-Current Turbine-Dynamos 165
Newspaper Conveyor 166
New Apparatus and Appliances 167
New Books .... Adv. 62
Personal .... Adv. 62
Trade Publications .... Adv. 63
Business News .... Adv. 63

Gas Engine Auxiliary Plants.

The applicability of gas engines as emergency prime movers to plants normally run by water power is well illustrated in the Swiss transmission plant described in the leading article of this number. In this case, the engines are located in what is virtually a sub-station and belted to motor-generator sets, the motors of which are either assisted or entirely relieved by the gas engines when the condition of the water at the hydraulic power house requires it. Results obtained in the Swiss plant indicate that in this direction lie opportunities for gas engines that certainly have not been seized, if indeed they have received consideration at all, in this country.

When the power is transmitted from a hydraulic plant located where the operation of gas engines would scarcely be commercially feasible, as in the Goldach plant, then of course the distributing sub-station is the logical locality for the auxiliary gas engine equipment. But there are many water-powers of moderate or very variable output in the United States which might be utilized by providing an auxiliary gas engine equipment located directly in the hydraulic power house; these water-powers being now unused either because their size or the local market for current, or both, would not justify a sub-station and the operation of a steam plant at the water-power site is not practicable, or because conditions would not warrant putting in an auxiliary steam plant at all. In such cases it would seem that the gas engine has most attractive possibilities. It is unnecessary in the present state of the industry to explain in detail that gas engines are preferable to steam engines for intermittent service; this fact is universally recognized, and combining it with the additional facts of the superior efficiency of the gas engine and its commercial practicalness in very respectable sizes, the feasibility of utilizing moderate water-powers of the class described, by means of the gas engine's assistance, appears unquestionable.

◆

Fan Motors for 1903.

From the description of constructional details contained in our annual fan-motor article, which appears elsewhere in this number, it will be evident that few changes have been effected in those types of machine that have been built in previous years, the most conspicuous new features this year being in methods of application and of wind distribution. About the only departure from previous practice in the constructional details of motors appears to be the substitution in some cases of rectangular brushes for the round pencils so generally used hitherto on direct-current motors, and the wider use of machine winding for coils wound directly into the armature slots of bipolar machines. Otherwise these sturdy little motors are practically unchanged.

◆

Municipal Ownership.

The very much befogged question of municipal ownership of public utilities at this writing is receiving under the auspices of the New York Reform Club probably the most thorough and systematic consideration that has ever been given to it. Prominent engineers, editorial writers and students of municipal affairs are participating in the discussion, and strong arguments for and against municipal ownership are in process of delivery. Some of the utterances thus far heard are academic in many respects, others are either platitudinous or demagogic, and a few have been hopelessly partisan and prejudiced. This sort of "discussion" appears to be inevitably characteristic of any formal consideration on a large scale of any weighty question, and it is doubtless because of this that the solution of a problem such as municipal ownership is so seldom reached as the result of conferences attended by numerous delegates.

For example, at the convention now in progress, one speaker has indulged in irrelevant utterances on the subject of "commercial dukes and industrial princes more powerful than many of the Old World aristocracy," and the same speaker while pointing out that public ownership has no lobby expenses to provide for and no dividends to pay on watered stock, neglected to mention the political pets, ward heelers and similar time servers with whom, as a rule, municipal departments are notoriously cursed. Another speaker took the strange position that manufacturers of electrical apparatus will not make improvements in their apparatus except when forced to do so by private operating companies, and that a municipality cannot operate an electric light plant at as low a cost as a private corporation can. Obviously arbitrary declarations and the utterance of specious generalities cannot facilitate the solution of this or any problem.

But there are many speakers at the convention who have given the matter serious analytical consideration based on experience, and it is to be hoped that their efforts will at least partly relieve the present unsettled condition of the question and provide some tangible and logical ideas on which a majority of unprejudiced minds can agree. The only corrective suggestions thus far advanced are two by Mr. Victor Rosewater, editor of the Omaha *Daily Bee*, one to the effect that municipal operation of electric lighting and similar plants should be freed from politics by means of civil service requirements, and the other pointing out that it might be advantageous for the municipality to control the public utilities without actually owning and operating them.

It is self-evident that *if* a municipal lighting, water or other system were operated on business principles, absolutely free from political influences, a given amount and quality of service could be provided at less cost to the taxpayers than if it were purchased from a private corporation. In Detroit, it is declared by the Light Commissioner of that city, this result is being obtained. If he is not mistaken in this statement, it is evident that Detroit has a phenomenally exceptional municipal government; such results are only possible in a city plant that is completely and inflexibly divorced from politics. The real problem is not whether a municipality *can* operate a plant as cheaply as a company or not; neither is it a question of watered stock, industrial magnates, or the progressiveness of manufacturers. It all depends on the single herculean task of providing conditions under which a municipal system shall *necessarily* be operated as conscientiously and intelligently as any ordinary successful business enterprise is conducted. When this utopian state of affairs has been attained in any community, the municipal control of public utilities in that community will be economical to its taxpayers—but not otherwise.

The New Railway Association.

As announced elsewhere in this number, there was organized recently the American Railway Mechanical and Electrical Association, the avowed field of which is the engineering and practical operating side of electric railway work. The new organization is timely, and it has magnificent opportunities ahead of it if it will only recognize and grasp them. We are strongly of the opinion, however, that the association has seriously limited its usefulness by restricting to the companies the privilege of voting: it is rather inconsistent, too, to organize an engineering body and deprive engineer members of all voice in its official proceedings. The railway companies already have one association; if they are to control both, then there appears to be no strong reason for establishing the new one. An engineering committee or section forming a part of the older association would serve the same purpose and with less expense and probably greater facility. It is to be hoped that the new organization will remove its present handicap by extending to all of its members the privilege of participation in the direction of its affairs, following the precedent set by the National Electric Light Association.

To Inquiring Correspondents.

At the head of the page of Queries and Answers, in every number of this paper, appears a note to the effect that no communication that does not contain the full name and address of the writer will receive attention. That notification has been repeated on this page once or twice, but notwithstanding all this we receive occasionally a letter to which we are unable to reply because the writer has not supplied us with the necessary information as to his identity or his address, or both. Just why anyone who seeks technical or other information should be unwilling to sign his name to a request for such information is not clear; as we have stated before, all inquiries are answered by mail, only those of general interest being published, and we cannot very well reply by mail to unsigned letters or those devoid of local address. Furthermore, the inquiries that are published are signed only with initials, so that overmodest inquirers have no reason to anticipate public identification in any event.

The Double Commutator Motor.

The characteristics of a constant-potential direct-current motor with two commutators are evidently not fully understood by a good many practical workers, judging from the number of communications we receive on the subject. Of course, everyone knows that with the two commutators connected in series, the speed is approximately one-half the speed that is obtained when they are in parallel. But it is not generally appreciated that under this condition the machine only exerts one-half of its full power. This is true, however, as shown by the facts that the speed ratio is two to one, and the ratio of total armature currents is also two to one. The power of any machine is directly proportional to its speed, other things being unchanged; and the power of a motor is also very nearly proportional to its armature current, other things remaining unchanged.

The case under discussion will perhaps be clearer if a concrete example be considered. Suppose a four-pole 500-volt double-commutator motor to have 159 coils of two turns each in *each* of the two windings, and to require 25 amperes in each winding (50 ampere total) at full speed and full load; suppose each winding to be of the two-path type, and neglect armature losses for simplicity, as they affect the results very slightly. The intake with the commutators in parallel will be 25,000 watts, and the product of armature wires and current per wire 15,900. Now if the two armature windings be thrown in series, the speed will be halved, and if the driven apparatus be such that the load varies as the speed the load will be halved, making the intake 25 amperes, or 12,500 watts; but each winding will be carrying 25 amperes, just as in the first case when the motor was working at full load. It is evident therefore that the maximum ability of the machine is exactly halved by putting the commutators in series, no matter how the outside load may vary with regard to speed variations.

The torque exerted by a double-commutator motor under the two conditions mentioned is precisely the same. In the case just assumed, each winding carried 25 amperes, whether in parallel or in series, and there were consequently 15,900 ampere-conductors (conductors × current per conductor) on the armature in both cases. Torque is directly proportional to ampere-conductors, so long as the field strength remains unchanged, so that the torque of the armature with maximum current passing is exactly the same in series as in parallel, although the output of the machine is halved by the series grouping. It is obvious, therefore, that the double-commutator motor is admirably adapted for driving machines which must operate at two or more speeds and which require heavy torque at all speeds.

Reckless Expository Writing.

It is not to be expected that a man who undertakes to write an article or a book on any subject, technical or otherwise, shall be rigidly infallible or unlimitedly learned; but the buyer of printed matter has the right to expect that the author of it shall not undertake to discuss, with an air of authoritative finality, any phases or branches of a subject concerning which he is not thoroughly informed. If a writer *will* talk about things on which he is hazy, he owes it to his audience to say frankly that his utterances are speculative, or at least without the basis of actual experience or observation. Unfortunately, many otherwise excellent writers appear to feel that the confession of fallibility in the slightest degree would detract from their standing or influence. The result is that books appear at frequent intervals containing absurdities or inaccuracies—perhaps only a very few of them—which either destroy confidence in the entire book or grievously mislead the reader, according to the extent of his training on the subjects discussed.

DESIGN FOR A ½-H.P. SELF-STARTING SINGLE-PHASE INDUCTION MOTOR.

The accompanying drawings give all of the essential features of a self-starting induction motor capable of giving one-half brake horse-power on a single-phase circuit of 100 volts and 125 to 133 cycles. The speed of the machine will depend, of course, primarily upon the frequency of the supply current. The synchronous speed at 125 cycles is 3750, and at 133 cycles it is 4000 r.p.m. The actual full-load speed will be something like 3300 r.p.m. at 125 cycles and about 3500 r.p.m. at 133 cycles.

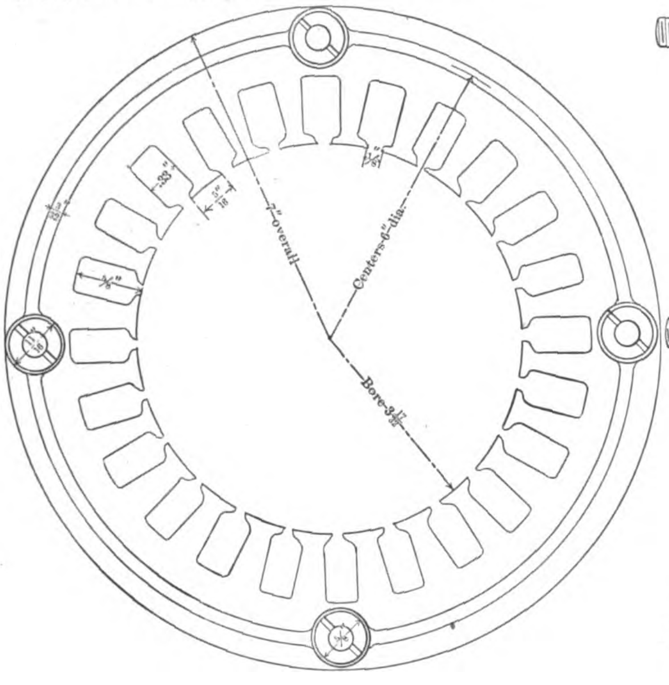


FIG. I.—END VIEW OF STATOR.

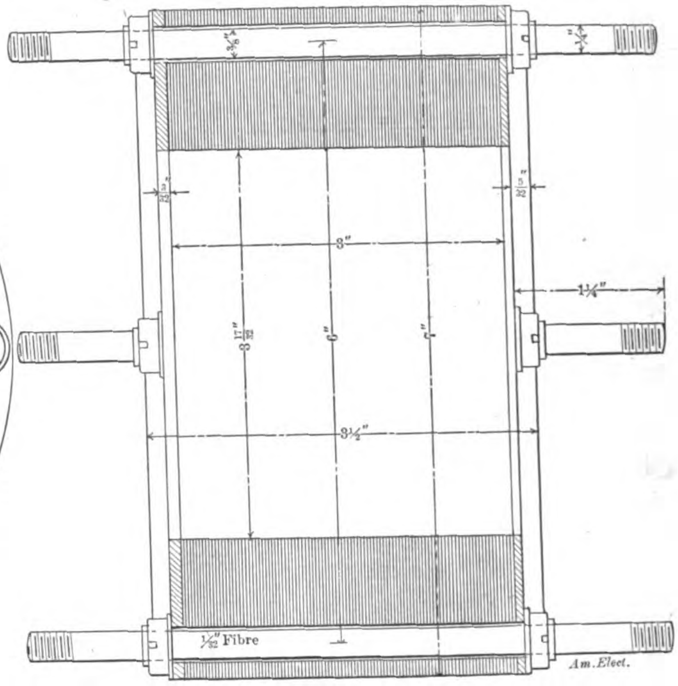


FIG. 2.—AXIAL SECTION OF STATOR.

Fig. 1 is an end view of the stator and Fig. 2 is an axial section of it, showing the arrangement of the brass end plates and the bolts that hold the structure together. The stator core is built up of 108 discs of sheet steel, each 25 mils thick, and allowing for scale and irregularities, the mass should be drawn together tightly enough to make the axial thickness 3 inches, as indicated in the engraving. The stator discs are 7 inches in diameter outside, and the hole in the center is 3 17/32 inches in diameter; this latter measurement must be absolutely exact. The 24 slots around the edge of the central hole are to be punched by means of the simple punch and die shown by Figs. 3 and 4, these being used in a step-by-step notching press. It is not assumed that the builder will possess one of these presses or buy one for the purpose of building this one motor; but he can easily make the punch and die and have the work done at some shop where such presses are in use.

The punch is built up in three pieces, a shank and holder plate of cast iron, a punch pad of ordinary machine steel, and the punch proper, of annealed steel. The punch pad is a simple rectangular plate in the center of which is worked a socket for the punch, the outline of this socket being the same as that of the main portion of the opening in the die. The punch is, of course, of the same outline on its face as the complete opening in the die, and the upper part of it is to be made a very snug fit in the hole in the punch pad. The latter is secured to the punch holder by means of four ¼-in. flat-head machine screws. In machining the holder, great care must be taken to have the face of it absolutely at right angles with the axis of the shank. The wall of the socket in the punch pad must also be precisely at right angles with the face that matches the face of the holder plate.

Fig. 3 shows the punch pad partly unscrewed from the holder, and the punch removed from its socket; it is held in the socket by means of a ¼-in. round-nosed set screw, and a depression should be machined in the side of the punch to allow the nose of the set-screw to seat itself without having to burr the punch. After the punch has been filed to shape, it must be tempered. In first hardening it, the steel should be heated to a bright red and "quenched" in oil or lukewarm water; if very cold water is used, the steel will be too brittle. The temper should be drawn in the flame of a Bunsen burner, and the steel should be wiped frequently with an oily rag during the heating. If the reader is not familiar with the process of "drawing" the temper of tool steel, he had better get this done by an experienced workman.

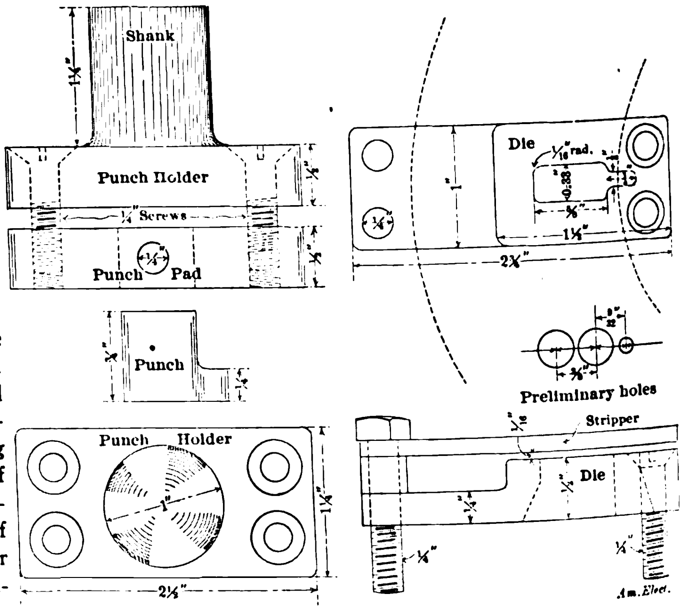


FIG. 3.—PUNCH AND DIE.—FIG. 4.

The die is to be made of annealed steel, of the quality used for this class of work (any dealer will supply the proper quality if told what it is to be used for). The sketches show clearly the shape and dimensions of the die. The dotted-line arcs in the upper part of the drawing indicate the inner and outer edges of the stator disc when in position for punching. The hole in the die may be most readily cut by first drilling two holes ⅜ in. in diameter and one hole ⅛ in. in diameter along a straight line scribed on the face of the die block; the distances from center to center of these holes are stated in the supplementary sketch between the plan view and the side view of the die. Having drilled these three holes, the superfluous metal must be filed away slowly and very carefully until the desired shape of slot is obtained. Then the hole must be enlarged on the under side of the die block in order to give clearance for the small pieces punched out of the stator discs to free themselves.

The die is bolted to the bolster (which need not be made by the amateur, as the shop in which the punching is done will have bolsters from which an appropriate selection may be made) by means of two cap screws and two flat-head machine screws. The cap screws also hold the stripper plate, which is a rectangular steel plate ⅛ in. thick and of the same outline as the base of the die block; it must have a hole cut in it which will come directly over the hole in the die, but the hole in the stripper need not be accurately machined to the shape of the punch; it may be a simple rectangular aperture ⅜ in. wide and 1 in. long. After the hole in the die has been finished to fit snugly about the punch, which must touch *every part* of the wall of the die hole, the die is to be tempered. The remarks concerning the tempering of the punch apply also to the die.

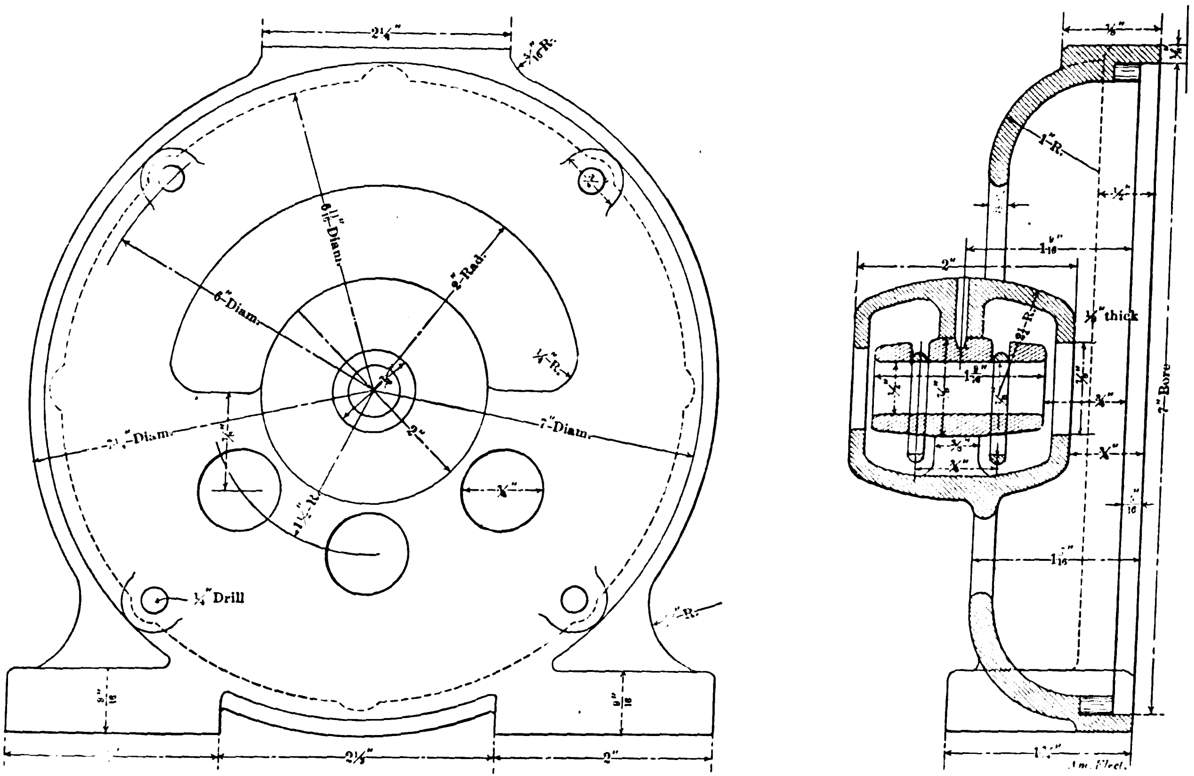


FIG. 5.—ELEVATION AND SECTIONAL VIEW OF ONE END CAP.—FIG. 6.

The brass end plates are cast with the slots in them, the sizes of the slots in these plates being a trifle full, as compared with the punched slots in the core discs. It will not do to use a simple brass ring of an internal diameter large enough to clear the slots in the core; the teeth between these slots must be clamped together tightly along with the body portion in order to reduce as far as possible the humming of the machine when in operation. In assembling the core discs between the brass end plates, the structure must be clamped together by means of two heavy cast-iron discs 5 inches in diameter and a 1-in. bolt through the center; this work may be facilitated greatly by the use of ordinary iron clamps such as are found in all machine shops, applying these at points around the outer edge of the stator in order to even up the compression and assist the central clamping bolt. After the discs are drawn to position, the holes near the outer edge may be drilled; if the brass end plates have been made of a hard alloy, the top one will serve as a jig for the drill. In this event it should be drilled before assembling the core discs, but the under plate should be left undrilled; when the discs are assembled, the holes may be drilled clear through them and the under brass plate. A much safer plan, however, is to make a cast-iron jig plate and clamp the discs between it and a plain cast-iron plate for drilling; the brass end plates should be drilled by the same jig plate, but separately.

The four ⅜-in. bolts which hold the stator core together also serve to hold the journal brackets or end caps in place. Fig. 5 shows one of these end caps and Fig. 6 is an axial section through the center of it. The drawings require no explanation beyond saying that the caps are to be made of cast iron. (Figs. 1 and 2 show the stator turned 45° from the position that it occupies when clamped between the journal brackets, or end caps, this being done to show the bolts in the sectional view.)

The journal sleeves shown in the engraving are of the self-aligning type, but if the reader is not very skillful at machine tool work it will be preferable to make them perfectly straight, making the outer diameter of the sleeves ⅞ in. the whole length. No pulley has been shown, as this can be bought for less than it would cost an amateur to make it. The proper size is 2½ or 2¾ in. diameter at the crown and 1½ in. width of face.

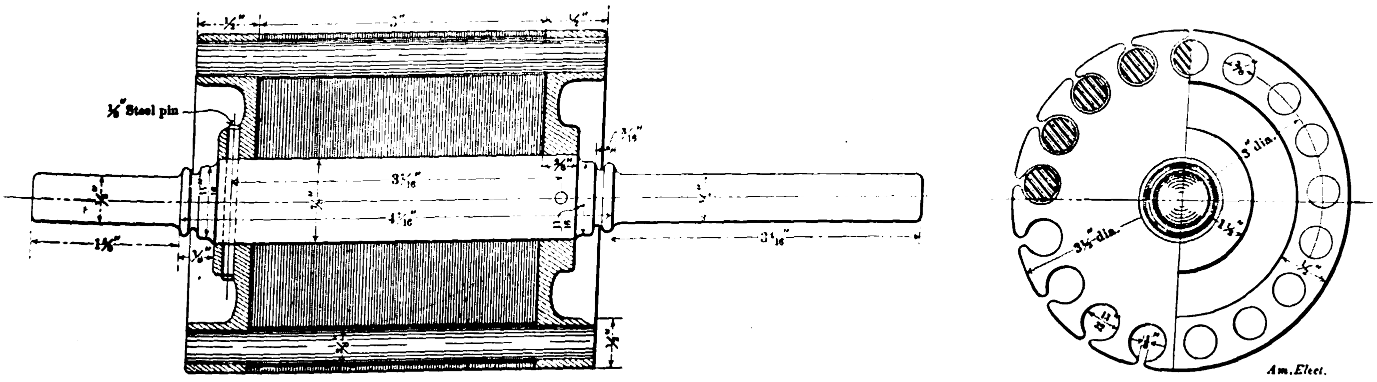


FIG. 7.—AXIAL SECTION AND END VIEW OF ROTOR.—FIG. 8.

The rotor is shown by Figs. 7 and 8. It consists of 108 discs of sheet steel clamped on the shaft between two cast brass end plates, which also serve to connect the ends of the rotor conductors. There are 17 of these, each ⅜ in. in diameter and 4 in. long; the holes in the rotor discs are 13/32 in. in diameter, and may be drilled with the aid of two cast-iron plates between which the discs are temporarily clamped, one of the cast-iron plates to be previously drilled so as to serve as a jig for the drill when the discs are drilled.

After the stator is finished the slots and end surfaces of the core should be insulated by means of red rope paper 0.015 in. (15 mils) thick, which should be thoroughly varnished with shellac before being put in place. The main stator winding consists of four sections or coils of 56 turns each of No. 14 double cotton-covered magnet wire, but this should not be put on until the starting winding is in place. This winding consists of four coils of No. 14 wire, each having 28 turns. Each of these coils should be wound into the proper slots over two blocks of wood (one at each end of the core) which will cause the coils to project ¾ in. beyond the face of the stator end plates, as indicated in Fig. 9. After they are wound in place, these projecting ends are to be bent upward out of the way of the main coils, which must be wound in the slots between those of the starting winding. Fig. 10 indicates this bending upward of the starting coils, and also shows the slots into which they are to be wound. They are connected in series with each other, and the connections must be such that if direct current were passed through this winding it would produce alternate north and south poles within the four coils.

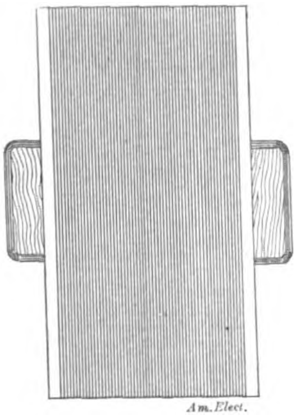


FIG. 9.—WINDING BLOCK.

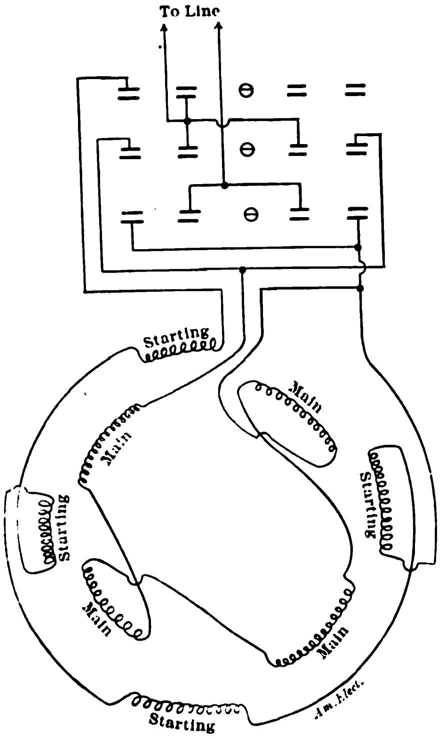


FIG. 11.—STATOR CONNECTIONS.

After the starting winding is in place and connected up, the main coils should be wound into their slots; two thicknesses of varnished muslin must be laid over the exposed parts of the starting winding just before commencing the winding in of the main coils. These coils are to be wound in their slots as indicated by the elementary diagram, Fig. 10; this shows only one turn in each slot, but the reader will of course understand that 26 turns are to be wound in the inner pair of slots *I, I,* before any wire is wound in the outer pair, *II, II.* The coils of the main winding, like those of the starting winding, must be connected up in series and in such wise that direct current passing through them would produce four magnetic poles of alternate polarity: north, south, north, south. It makes no difference what the relation is between the direction of the starting coils and that of the main coils; the terminals must be carried out to a three-pole, double-throw knife-blade switch, as indicated in Fig. 11, and if the connections at first made do not start the motor in the direction in which it is intended or desired to run, it may be reversed by merely reversing the leads from either the main winding or the starting winding, but not both. The switch should be mounted so that the throw is horizontal (unless an additional main switch is provided), in order that it may be left open without danger of accidentally closing by gravity. As the diagram is drawn, throwing the switch to the left puts in both windings, for starting up; when the machine attains something like normal speed, the switch should be thrown quickly to the other side, leaving only the main winding in circuit.

If the builder prefers to use simpler apparatus, two ordinary double-pole switches may be used, one for the main winding and one for the starting winding, but this arrangement has the slight disadvantage that the user may close one switch and leave it closed for an appreciable length of time before closing the other, which might overheat the winding thus thrown in alone, as the motor would not start up and the winding would be provided with a short-circuited secondary—the rotor conductors. The result would be similar in kind, though less in degree, to that obtained by short-circuiting the secondary terminals of an ordinary transformer with the primary connected to the supply mains. The motor should not be started with any load on it except the countershaft to which it is belted. Even with that it will be found advisable to give the belt a strong pull, to overcome standing friction, when the motor is thrown into circuit.

A MODERN PRIVATE BRANCH TELEPHONE EXCHANGE.

BY A. DALLAM O'BRIEN.

When the number of stations to be connected to a private telephone system exceeds fifteen or twenty, the size and complication of the apparatus required at each station in an intercommunicating arrangement becomes the deciding factor in the establishment of a private exchange switchboard, and the fact that these private boards are usually connected by one or more trunk lines to some large central office has led to the classification of exchanges of this nature under the head of private branch exchanges. These private exchanges may have connected to them anywhere from two or three stations to two hundred stations, as may sometimes happen in the case of a large hotel. And the switchboard may be connected to the central office by from one to twenty or thirty trunk lines, depending on the volume of business to be handled. Such a system, of course, requires a switchboard and switchboard operator.

It is the purpose of this article to describe the methods of operation and wiring, and to some extent the construction of one of the most common types of private branch exchange switchboards, and to give in some detail instructions for the installation and maintenance of such systems. The switchboards themselves range in size from a box about 16 ins. x 24 ins. x 14 ins., fastened to the top of a table or desk and having a capacity for eight local and two trunk lines, up to an upright switchboard about six feet high and 30 ins. deep, measured from the front of the keyboard to the back of the switchboard, and about 30 inches wide across the face. A board of this latter size will accommodate 90 local lines and 10 trunk lines.

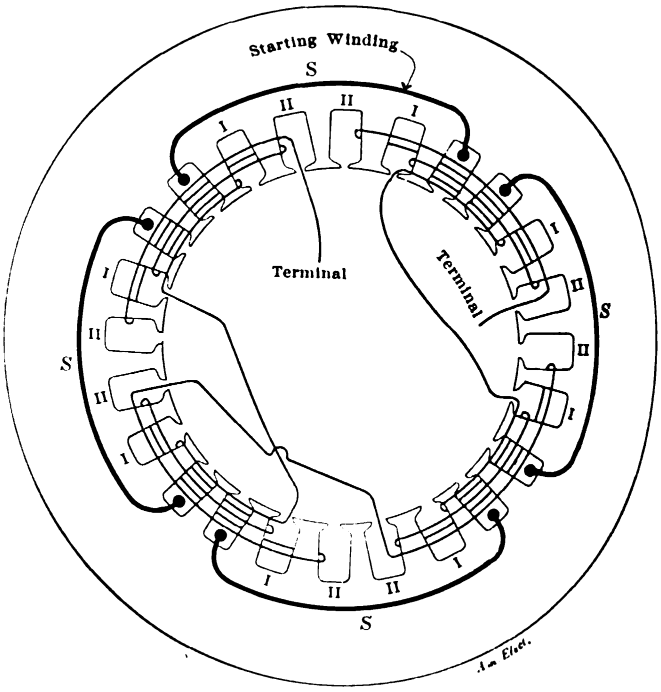


FIG. 10.—STATOR WINDING.

Since the common battery system has come into general use in central offices, the old local battery or magneto system of private exchanges has been replaced by the more modern central energy type of switchboard, which is in its way quite as complete as the modern central office equipment. In Fig. 1 is shown a front elevation and side section of a modern 100-line private exchange board. To the connecting rack shown in the figure are connected all the lines coming to the switchboard. This rack is made of 1-in. maple, and is drilled with holes on centers, as indicated by the crossed lines in Fig. 2. Through these holes are passed lugs, one of which is shown in Fig. 3, and these are then screwed fast to the rack. On one side of this rack all the lines coming to the switchboard are soldered, each pair of line wires being fastened to a pair of lugs. The rack is usually numbered so that the lugs count in pairs from left to right, and from top to bottom, facing the front of the board.

To the other ends of the lugs is connected a cable consisting of twisted pairs of No. 22 double cotton-covered wire. This cable is then led up the side of the board and the free ends "fanned" out, the pairs being connected to the outside springs of 4-point jacks. All connections to jacks and lugs should be well soldered. The pair of wires that is connected to No. 1 pair of lugs is connected to No. 1 jack, and so on, the number of each line being the same at every point where identification is requisite. From each jack a single wire is carried to its corresponding drop, these wires being formed into a cable and led up the side of the cabinet. Each of these cabled conductors from the jacks to the drops is soldered at one end to one of the inner contacts of the jack and at the other end to one end of the winding of the drop. The connections of the remaining contact on the jack and the other end of the drop winding will be seen later.

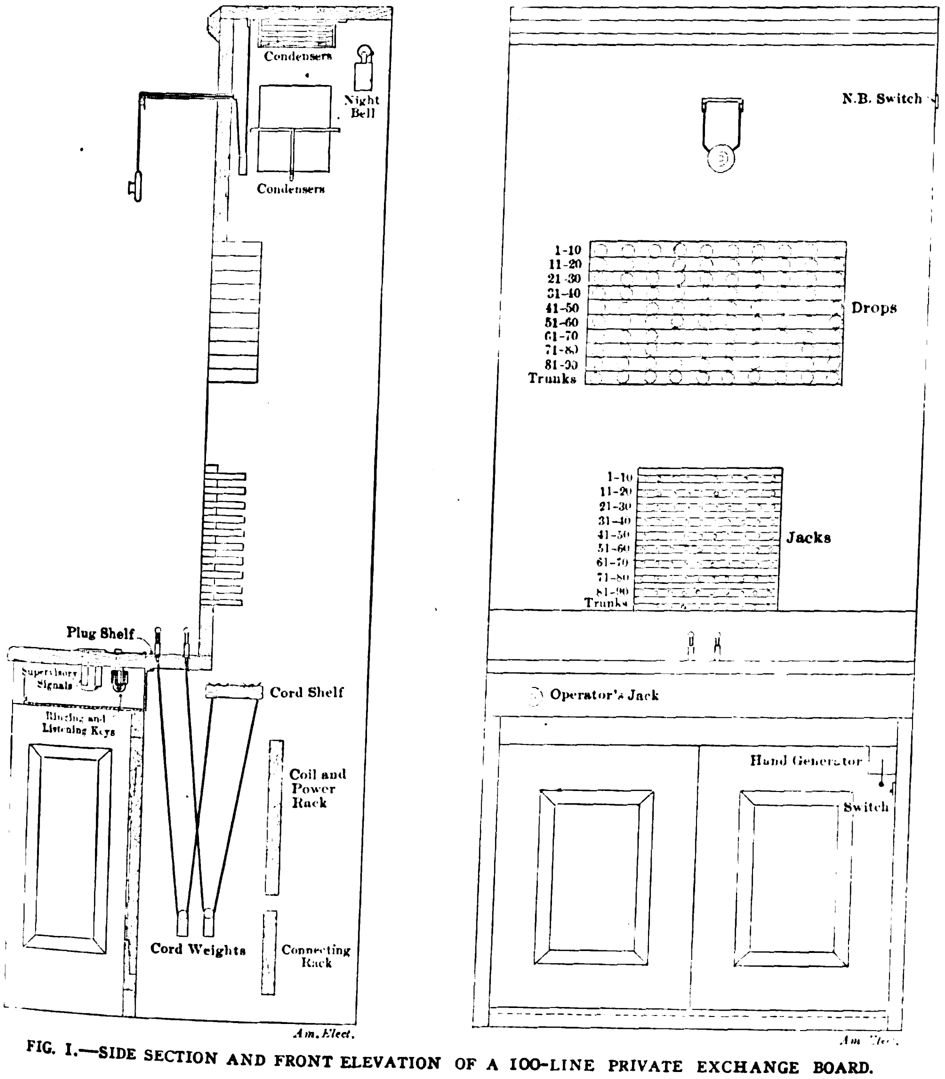


FIG. 1.—SIDE SECTION AND FRONT ELEVATION OF A 100-LINE PRIVATE EXCHANGE BOARD.

Above the connecting rack is placed a second board of 1-in. maple, and to this board are fastened the repeating coils used in the cord circuits and the induction coil and retardation coil or coils necessary for the operator's telephone. These coils are mounted on the front side of this board, as indicated in Fig. 4. On the back of this board are mounted two copper bus-bars about 12 ins. long, ½ in. wide and ⅛ in. thick, and these bars carry the current from the batteries to supply the board. These bars are mounted about three inches apart, and parallel with each bar there is a strip of hard rubber or other insulating material, as shown in Fig. 4. To each insulating strip are attached lugs, one end of each lug being connected by No. 12 rubber-covered wire to a repeating coil, and the other end connected to the bus-bars through 1-ampere fuses. At the bottom of the connecting rack are mounted eight or ten lugs separated from the line lugs and designated in Fig. 2 "Locals." These lugs are used as connectors for the operator's telephone circuit, and one pair of them is used to carry the ringing current for the board, this current usually being furnished by means of a pair of wires from the central office.

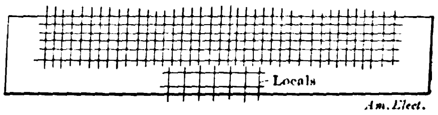


FIG. 2.—CONNECTING RACK.

The operator is also furnished with a hand generator mounted on the front of the cabinet, as shown in Fig. 1, to be used for signaling in case of failure of the central office supply. In order that the operator at the board may be notified of a call on one of the lines when her attention is not directed to the drops, an extra contact is placed under the front face of the drop and the iron strip on which the drops are mounted is connected to the negative bus-bar of the battery. The extra contact on the drop is wired through a switch to a bell mounted inside the board, this bell having one terminal connected to the positive bus-bar. Thus the falling of a drop shutter, which is in metallic connection with the drop mounting and hence the negative bus-bar, completes a circuit through the bell and notifies the operator. This bell can be cut in or out of circuit by means of the switch. The wiring of this circuit is completely shown in the night bell circuit in Fig. 5.

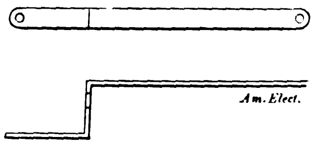


FIG. 3.—LUG FOR CONNECTING RACK.

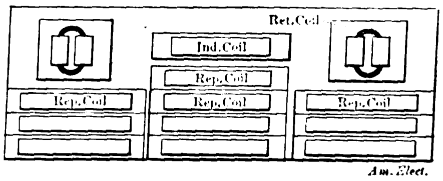


FIG. 4.—FRONT OF COIL RACK.

The batteries used for these boards are either of the Fuller type or are storage cells. In cases where storage cells are used, the cells are generally charged over a pair of wires from the central office battery. There being a considerable drop in voltage from the battery at the central office through the line to the battery at the branch exchange, it is usual to install five or six storage cells in series at the branch exchange, thus making the normal e. m. f. there about twelve volts. The normal volt-

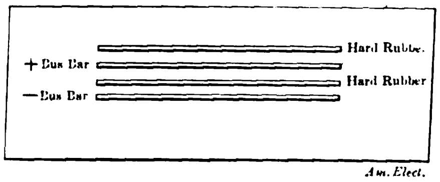


FIG. 4A.—REAR OF COIL RACK.

age at the central office is about 22 volts, and allowing a drop of, say, seven volts in the line the branch exchange cells will charge at 15 volts. The charging should preferably be done at a certain time each day, but it is usual to connect the leads from the central office through a switch, so that the branch exchange battery may be charged as occasion requires. Where Fuller cells are used the only attention necessary is an occasional renewal of the zincs and an addition to the battery solution to take care of evaporation. The general practice is in favor of storage cells, and they are being installed very largely. The batteries are mounted in a battery box as close to the switchboard as is practicable, and leads of No. 8 rubber-covered wire are carried direct to the bus-bars on the rear of the coil rack.

In wiring large buildings for a private branch exchange system, a large cable is led from the connecting rack to some central point on the floor with the switchboard. An elevator or air-shaft is usually chosen. At this point the cable is "fanned out," and connected to a terminal panel in a junction box, and from this box smaller cables are led to branch junction boxes at the various floors and the connections to the different instruments made from these branch boxes. In this way, if any pair in the cable should develop a fault the instrument working on that pair can be at once transferred to another pair at the junction box and its service continued.

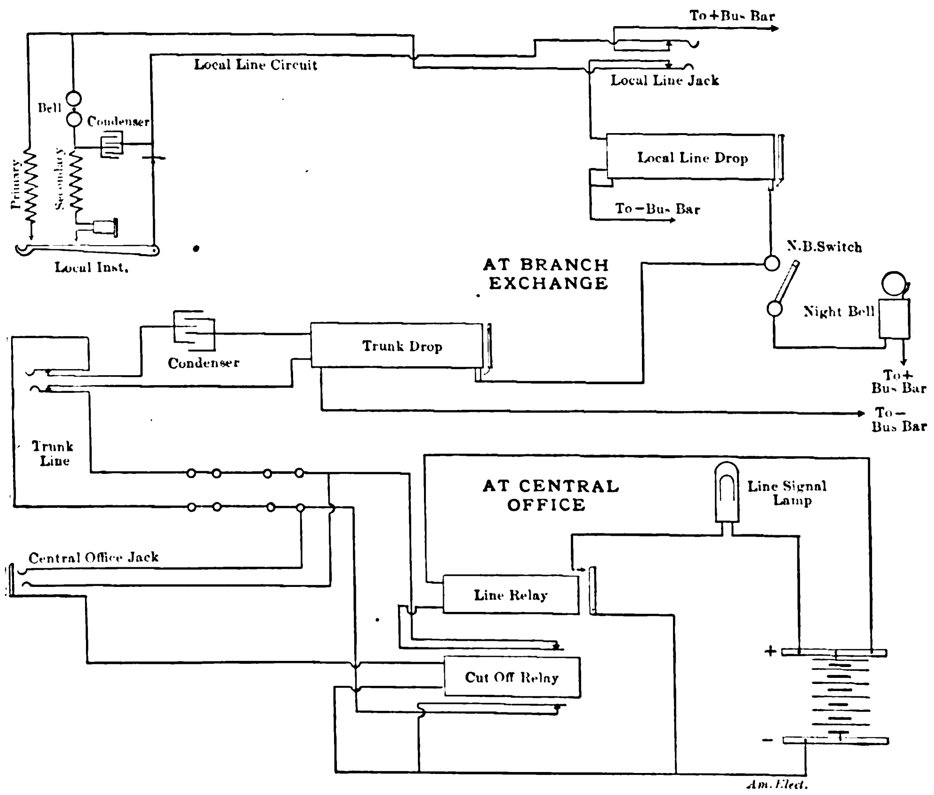


FIG. 5.—TRUNK CIRCUIT TO CENTRAL OFFICE.

The keyboard equipment consists of ringing and listening keys, connecting cords and supervisory signals. Each cord is equipped with a ringing key and a supervisory signal, and in addition, each *pair* of cords is provided with a repeating coil and a listening key. The keyboard is hinged at a point about one-quarter of its width from the face of the board, and on this portion are mounted the ringing and listenings keys, as shown in Fig. 1. The strip at the back of the keyboard is known as the plug shelf, it being drilled to receive the plugs and to allow the cords to extend through to the inner part of the board. The cords themselves are about four feet long, and each cord is provided with a weight of about six ounces, hung on a pulley that slides on the cord. This weight serves to seat the plugs on the plug shelf when they are not in use.

The free end of each cord is provided with two fasteners, there being two conductors in the cord, which are fastened by means of screws to lugs mounted on the cord shelf. From these lugs a cable of No. 22 twisted pairs is run to the ringing keys in the keyboard, and "fanned up" with this cable in the keyboard is another cable of switchboard wire leading from the ringing keys to the repeating coils. The proper terminals on the ringing keys are connected to their corresponding listening keys by means of No. 16 tinned copper wire, which is covered with corset lacing dipped in shellac. The ringing and listening key parts are assembled on one long mounting, and the 30 keys are mounted in the keyboard together. It is the usual practice to connect the listening key of a pair of cords to the ringing key of the back cord, the back cord being the one nearest the face of the board. There is no particular reason for this, however, as the listening key can be used on either the front or the back cord because of the derived circuit through the repeating coil.

Before taking up the circuits in detail, it will be well to consider the work of the operator in handling calls of different kinds. The removal of the telephone from the hook at any local station throws the corresponding drop at the switchboard. The operator answers by placing the rear plug of any pair into the jack of the line calling, and then throws the listening key, thus putting herself in connection with the calling station. If the connection required be a local one, the operator places the front plug of the same pair into the jack of the line desired and presses the ringing key of that cord. When the called station answers, the target of the supervisory signal is displayed and the operator knows that the connection is established. Upon the termination of the conversation the targets of the signals of both the front and rear cords should drop. If one of these targets should fail to drop, the operator throws her listening key and inquires as to the number wanted. Either station may at any time during conversation signal the operator by working the hook-switch at the instrument, this action flopping the supervisory target at the switchboard.

In case the connection desired is one that must be obtained through the central office the local operator has two methods of procedure open; she may place the front plug of the pair to which the calling station is connected into the jack of a trunk line to the central office and allow the subscriber to ask the central office operator for the number required, or she may use another pair of plugs, obtain the required number herself and then substitute for the plug used the mate of the plug on which the calling subscriber is held. On connection to the central office the branch exchange operator disconnects when the target of the supervisory signal on the cord of the local station falls. The target on the cord connected to the central office trunk will not fall, as an inspection of the diagram of a central office trunk line will show.

In Fig. 5 is shown the circuit of a local line to the switchboard. When the subscriber removes the telephone from the hook at the local station current flows from the positive bus-bar to the inner contact of the jack, thence through the outer spring over the line through the subscriber's instrument back through the jack and drop to the negative bus-bar. When the operator answers by placing a plug in the jack, the plug presses outward the two outer springs of the jack and breaks the inner contacts, cutting off the flow of current through the drop, which can then be restored to its normal position.

Fig. 6 shows an operator's cord circuit and the operator's telephone circuit. Upon receiving a call the operator places the answering plug in the jack of the line calling; she then throws her listening key, thus throwing the inner springs of the key in contact with the outer springs and putting her telephone in connection with the subscriber through the ringing key, plug and jack. Having obtained from the calling party the number required, if the number be a local one, she places the other plug of the pair into the jack of the line required and presses the ringing key of that plug, thus breaking the contact between the long springs of the key and the inner contacts, and putting the long springs in contact with the outer springs to which an alternating-current generator is attached. Alternating current flows out through the plug and jack over the line to the subscriber's instrument, and the telephone being on the hook and the contact open, its only passage is through the condenser and bell, and thence back to the generator. The operator, having rung, releases the key, which comes back to its normal position.

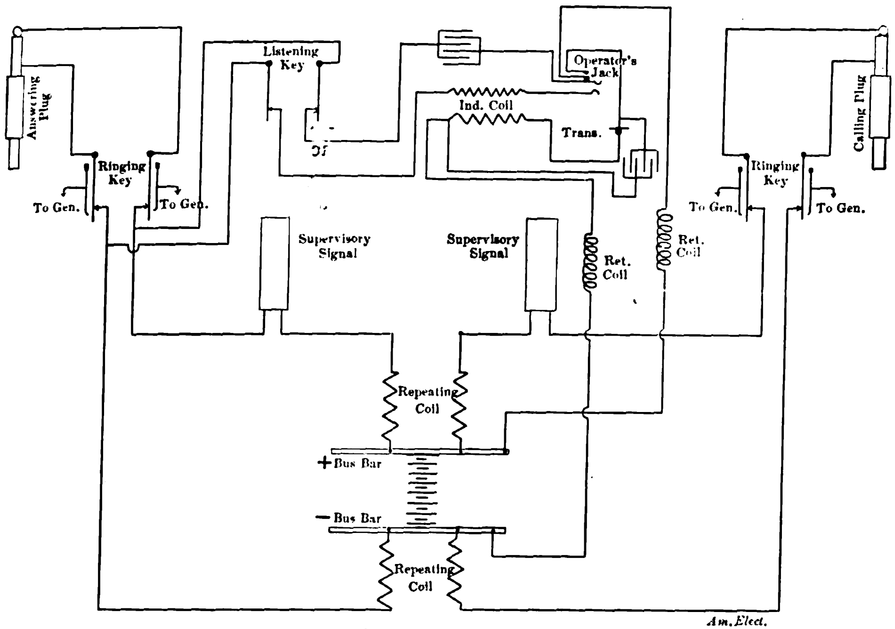


FIG. 6.—OPERATOR'S CORD AND TELEPHONE CIRCUIT.

When the called subscriber answers, current flows from the positive bus-bar through one winding of the repeating coil, through the winding of the supervisory signal magnet, thence through the instrument and back through the other winding of the repeating coil to the negative bus-bar. The current flowing through the winding of the supervisory signal magnetizes it, and it attracts its armature, the movement of which raises into view in the keyboard a small aluminum target. Conversation is carried on by the subscriber through the repeating coil. Variations in the potentials at the bus-bar may occur from time to time, and if means were not taken to prevent it these variations would affect the operator's telephone and cause the phenomenon known as "cross talk," and make it at times almost impossible for the operator to distinguish what was being said to her. To prevent this effect, a retardation or choke coil is placed in series with the operator's transmitter and the primary of her induction coil.

In the circuit shown in Fig. 6 two choke coils are used, one on either side of the battery. The effect of the choke coil is to check any variations that may tend to occur. The fact being, however, that it is the variation in current caused by the changes of resistance in the operator's transmitter that enable her to converse with subscribers, some means must be used to kill off only the objectionable variations at the bus-bars and allow the useful variations to be effective. This result is obtained by connecting a condenser around the transmitter and primary of the induction coil. The condenser in the secondary circuit is used merely to keep the direct current from the battery from flowing through the operator's receiver when her listening key is thrown. When the subscribers finish their conversation and hang up their instruments the circuit is opened at the hooks, current ceases to flow through the supervisory relay, which releases its armature, the target drops and the operator disconnects.

In case the connection desired is one that must be obtained through the central office, the branch operator places a plug in the jack of a line to the central office, but does not ring. An inspection of Fig. 6 will show what occurs. Current from the positive bus-bar of the central battery flows through the line relay and contacts of the cut-off relay at the central office over the line through the jack and cord, repeating coil and battery at the branch exchange; and thence back over the line and through the contacts of the cut-off relay to the negative bus-bar. The current flowing through the line relay energizes it and it attracts its armature, thus closing the circuit through the line signal lamp which is mounted immediately below the branch answering jack at the central office. This signal lamp lighting up attracts the attention of the central office operator, who answers by placing a plug in the jack. The central office operator's plug has three contacts; the one that makes connection with the sleeve of the central jack is connected to the positive bus-bar. Hence, when the plug is placed in the jack current flows through the sleeve through the winding of the cut-off relay to the negative bus-bar. The cut-off relay being energized attracts its armatures (the two inside springs) and breaks their contacts, thus opening the circuit of the line relay which in turn opens the lamp circuit and extinguishes the lamp. The current is then carried from the central office jack through the intermediate and main distributing frames, to the jack at the branch exchange. On calls from the central office to the branch it is necessary for the exchange operator to ring, as a condenser is in circuit with the trunk drop. If this condenser were not in circuit, current would be continually flowing though the line relay, over the line, and through the drop at the branch exchange, thus keeping the line signal at the central office constantly lighted. In Fig. 7 is shown the arrangement of the circuit for changing from power to hand generator.

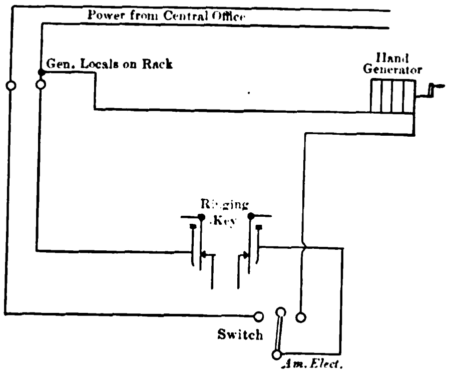


FIG. 7.—CIRCUIT FOR CHANGING FROM POWER TO HAND GENERATOR.

The drops used in the board shown are 500-ohm tubular drops and are used to a very large extent in boards of this kind. The supervisory signal magnets are wound to a resistance of 60 ohms, and are so adjusted that they will operate on a circuit up to 600 ohms resistance, and that the armature will fall when the resistance rises to 2600 ohms. The repeating coils have a resistance of 40 ohms per winding, the four windings being wound on the same core and being covered with an iron shell to give a completely closed magnetic circuit and avoid any interference from outside currents. The resistance of the operator's induction coil varies in different types of boards; very good results can be obtained with a coil having a primary of ½ ohm and a secondary of 150 ohms. The method of bringing the local lines to the switchboard can best be determined by a study of the conditions of each particular case; no general rule will cover all cases. It is an excellent plan to separate the trunks from the local lines on the rack and to stamp the number of each pair between its lugs.

The board here presented is one that has been used extensively and has given most excellent service in every particular. The writer some years ago installed a number of these boards for a Bell company, their capacity in some cases reaching 200 lines. Small boards must be built to suit the installation and the equipment they are intended to use. The maintenance of these boards consists of an occasional adjustment of the key springs, adjustment of the supervisory signals and attention to the batteries. The tubular drop requires little or no attention, and accidents to the wiring are things that cannot be foreseen.

AN ELECTRIC TRAIN INDICATOR.

BY E. C. PARHAM.

The object of the device herein described is to provide a simple and certain means, whereby passengers, waiting on the platform or in the waiting room of a station used in common by patrons of several lines of trains passing that station but having different destinations, may, without danger or inconvenience to themselves or other passengers, tell the destination of an approaching train, independently of colored lights, colored signs or any other destination markers carried by the train itself.

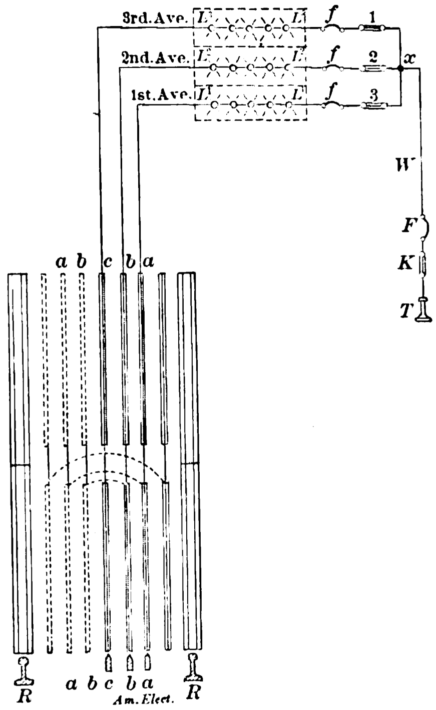


FIG. 1.—ELECTRIC TRAIN INDICATOR.

In Fig. 1, *R*, *R*, represent the track rails of the railway roadbed, *a*, *a*, *b*, *b*, and *c* are strips of metal of the cross-section indicated or of any other cross-section that would be effective in preventing the formation of a film of ice on the upper edges of the strips, which are, under conditions to be explained later, to deliver a small electric current to a contact sliding or rolling upon them; *T* is a third rail, or other source of electric current; *K* is an electric switch, and *F* a fuse; both are in the trunk wire. *W*, leading from the current source, *T* to *x*, the common junction of several lamp circuits that begin at that point; 1, 2 and 3 are ordinary lamp switches by means of which the individual lamp circuits can be interrupted independently of main switch, *K*, and *f*, *f*, *f* are individual circuit fuses.

The lamps *L*1, *L*2, *L*3, respectively, when lighted, throw light on the fronts of the respective sign boxes that contain them. The sign boxes are of a type well known to the art. It is preferable that the frosted parts of the sign box glass fronts be of a dark color, so that the sign may be effective day and night. The desired frosting effect can be cheaply obtained by cutting in on clear glass the desired lettering with a dark dense paint.

Metal strips, *a*, *a*, *b*, *b*, etc., are secured to the cross ties or other substructure by means of suitable flanges or pieces cast integral with or separate from the metal strips, or in any other simple manner that local conditions may suggest. The metal strips are laid in sections of any convenient length and all strips belonging to the same lamp circuit are bonded together as indicated. In cases where trains shuttle back and forth between terminii, only the strips and bonds shown by the full lines are needed to correctly indicate the several destinations of the lines of trains. In such cases there need be only as many continuous lines of metal strips as there are destinations to be indicated. When, however, trains use a loop or Y at either terminal, all metal strips must be symmetrically duplicated in regard to the opposite track rail and signal strips parallel and involved in the signaling of the same destination must be connected as indicated by the dotted lines. Where some trains loop or Y and others do not, only those that do require parallel duplication of their signal strips.

The total length of signal strip track space to be covered depends upon the distance at which the destination of an approaching train is to be announced by its destination sign. It is recommended that the signal strips begin on the station side of the point at which engineers ordinarily make their first application of the brake preparatory to making the station stop, and that they end at such a distance from the station that the last car of the shortest standard train shall overhang the signal strips when the station stop is made.

In Fig. 1 only three sets of strips and three destination signs marked First Avenue, Second Avenue and Third Avenue, respectively, are shown, but, of course, there may be as many sets of strips as the width of space covered by a car-body will permit, and as many destination signs as there are sets of strips. In Fig. 1 the negative end of the lamp circuit that lights the First Avenue sign connects to strips *a*, *a*, *a*; the negative end of the Second Avenue signal circuit connects to strips *b*, *b*, *b*, and that of the Third Avenue sign connects similarly to signal strips *c*, *c*, *c*. It is evident that when all lamp circuit switches are closed and all fuses intact, all destination sign lamp circuits are alive down to and including the signal strips to which they are respectively connected. It can be further seen that any lamp circuit can be made to pass a current and thereby light its lamps, thus illuminating its destination sign, simply by grounding the signal strip to which the lamp circuit connects.

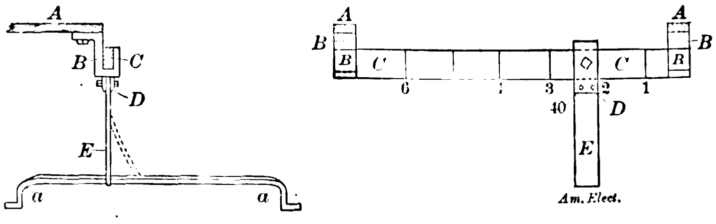


FIG. 2.—TRANSVERSE BAR AND CONTACT SHOE.

The grounding of the proper signal strip at the proper time is effected by means of a sliding or rolling contact carried on the bar, supported by the truck or the under side of the car-body of at least one car and preferably two cars of every train the destination of which is to be announced, the bar, if one be used, being supported at right angles to the direction of motion of the train; it is a simple matter to provide the contact shoe or wheel with a suitable clamp whereby it can be secured in any desired position within the length of the bar. The object of such lateral adjustment is, of course, to arrange the shoe or wheel on any given train so that it will make contact only with the proper signal strip.

Fig. 2 shows an arrangement of the transverse bar and contact shoe that is practicable where there are no obstructions between the track rails along the line of route to interfere with the contact shoe when it is permanently adjusted to make the proper contact with the desired signal strip; *A* is any one of the truck bars least influenced by variations in live load; *B*, *B* indicate hangers, in which rests the transverse shoe bar *C*, shouldered on both ends to prevent lateral motion; *D* is a sliding clamp which, by means of a set screw can be secured in any desired position on the bar *C*. The lower end of *D* clamps, by means of bolts and nuts, a spring copper contact shoe *E*. The marks 1, 2, 3, 4, 5 and 6, on the bar, indicate the positions for the clamp *D*, the distance between these marks being the same as that between the corresponding signal strips in Fig. 1. Normally, the position of shoe *E* is vertical, but upon engaging any signal strip, such as *a a*, it assumes the bent position indicated by the dotted lines.

It is, of course, not necessary that all cars be equipped with the bar and shoe, but it is advisable that all motor cars be equipped with the hangers *B*, so that any car may be provided with a bar and contact shoe. The head and rear motor cars should be provided with bars and shoes. Should a train change its destination after being placed in commission, it is an easy matter to slide the shoe over to the proper mark on the bar. Should a train be an express or cripple or shop train not intended to stop at any station in question, the shoe can be secured in between marks, so that it will engage no signal strips. Where trains round a loop or take a Y at either terminal, the labor of changing the position of the contact shoe, where there is only a single line of signal strip for each destination, can be avoided by using two shoes, symmetrically disposed in regard to the center of each bar. Where the signal strips are duplicated symmetrically, the single shoe will not, as implied before, require to be changed.

PARALLEL RUNNING OF ALTERNATORS.

BY W. T. FERNANDEZ.

Not many years ago the parallel running of alternators was a mysterious combination of tinkering with engines, junk on the governor, profanity and the delightful sensation of never knowing exactly where one was at.

We threw them together by lamps, held heated and violent conversation with the gentleman at the throttle, who would not "monkey with his throttle for nobody," and made strange guesses at power factor and engine speed.

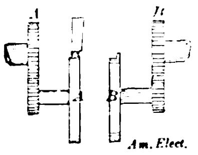


FIG. 1.

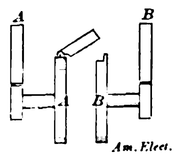


FIG. 2.

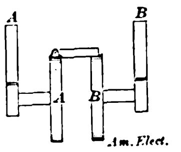


FIG. 3.

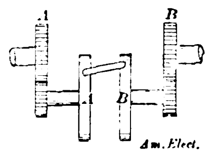


FIG. 4.

The writer has operated three 350-kw. 62½-cycle generators under difficulties. One generator was belted to a high-speed engine, the second to another high-speed engine, and the third to a counter shaft carrying 14 arc machines, with capacities of 35 to 100 lamps; the shaft being driven by a slow-speed Corliss engine. Speed adjustment was a prolific bone of contention between the engine and dynamo rooms until the writer discovered that it was possible to regulate the speed by shifting an arc circuit from one engine to another. No prior rights of engine speed control from the switchboard (?) are claimed on this account, the fact being merely mentioned to illustrate the changed methods of operating polyphase apparatus. That more judgment is required to operate alternators in parallel than direct current machines is self evident, but with a combination of elementary knowledge of the apparatus in hand and some "horse sense" the feat may be accomplished in a satisfactory manner.

A simple illustration of the relation of alternators in parallel will serve to show why it is necessary to alter the relative position of the field poles of parallel generators to vary the load on one of the pair. Suppose we have two disks, one fitted with a hinged and pivoted strap, each disk attached to a shaft, the free ends of which bear cogs meshing larger cogs, as shown in Fig. 1. Mark one disk generator *A* and the other generator *B;* one large cog, engine *A,* the other, engine *B.* The large cogs, driven by motors, may be rotated at varying speeds. A slot is provided in disk B to receive the free end of strap mounted on *A.*

A is rotated at full speed, and it is desired to connect *B* to it without a jar. Slowly increase the speed of *B* until the slot on *B* is parallel and rotating with the strap attached to *A.* As the strap and slot on a line with each other pass under the hand (Fig. 2) drop the strap into the slot and the generators are together, as shown in Fig. 3.

Since the generator *B* was running light before it was locked to *A,* the prime mover of *B* was not receiving as much steam as that of *A,* therefore to make *B* take a share of *A*'s load it is necessary to open wide the throttle and give *B* more steam.

As *B* picks up some of *A*'s load, *A* will show a tendency to move ahead of *B.* (An ideal engine would not do this, but the ideal engine has not arrived as yet.) It therefore becomes necessary to lessen *A*'s steam allowance a little, which brings it back to its former position in relation to *B.*

There is now a condition of even load and phase, and if the field excitation is uniform on both machines, there is a good power-factor between them. If the speed of *A* is increased a little, the strap assumes the position shown in Fig. 4, indicating that a given point on *A* is reaching a certain position an instant sooner than a similar point on *B,* or in other words, that *A* is doing its work a little earlier than *B,* and is not receiving the same amount of help from *B,* as before. If *B* is moved forward until the strap resumes its former position (Fig. 2) the generators are again doing equal shares of the work, but the speed of both is increased and the cycles are 25.5 instead of 25. *A* should, therefore, have been moved back instead of moving *B* forward, to keep synchronous apparatus, such as rotaries, synchronous motors, etc., at a uniform speed, so that as little adjustment as possible would be necessary to preserve a good power factor in the sub-stations.

If generators are substituted for the disks and a pole of one machine for the strap, and a similar pole of the other machine for the slot in the second disk, we have the actual relation of the poles of two or more generators in parallel; the operation of which means simply getting similar poles in a similar position in their relation to the armature coils and keeping them there, except for the slight variation forward or backward to load or unload one generator more than another.

Field excitation of parallel generators varies directly with the load. The generator carrying the heaviest load requires the strongest field. If the field excitation of two generators in parallel is equal and the load distributed, two-thirds on one machine and one-third on the other, more or less cross currents will flow between the two machines, causing unnecessary heating of the armature coils.

Power-factor indicators are direct indicators of field adjustment. The indicators of generators in parallel should read alike irrespective of the load on the different machines. This condition indicates a proper excitation for the load on each generator. When a generator is to be cut out, the power-factor should be kept where it was when the engine room was signaled to "lower," by slowly cutting down the excitation as the engine is throttled. Momentary cross currents, such as will flow if this rule is not followed, while not productive of any particular harm, are unnecessary in a station having an equipment of modern instruments.

Much of the difficulty of quickly getting in step when bringing a generator up to phase, is caused by too frequent and erratic alterations of the throttle or governor weights. When the generator is near phase, the adjustment should be very slight each time, and an allowance of from five to ten seconds should be given for the engine to settle before another change is made. Where generators are driven by engines built for parallel operation the task is a little easier, but good judgment at the throttle is essential to quick and accurate work with any engine driving an alternator about to be cut in on the bus. The writer has seen a 3500-kw. generator running at three-quarter speed, brought up to full speed, phased, cut in and loaded in one minute and thirty seconds in regular practice in a plant supplying a rotary system, without a variation of line pressure, as indicated by the recording chart of a voltmeter on the primary bus-bars.

The type of switch used must be considered when phasing with a voltmeter or synchronizer. Assuming a dark period is used and a hand switch, the switch must be thrown the instant the pointer reaches zero. If an electrically operated switch is used an interval of time must be allowed for the mechanism to act by the time the pointer reaches zero, in other words, the control switch should be thrown an instant before the pointer reaches zero. It will be found advisable if a synchronizer is used, to cut in when the pointer is rotating toward "fast" at a moderate rate of speed. The generator will take a little load at once and steady the prime mover, preventing any fluctuation of line pressure; a thing to be avoided on a lighting system. Fig. 4 shows the synchronizing arrangement usually installed for three-phase work, consisting of a lamp in series with a second lamp on the engine at the throttle, a synchronizer and voltmeter. The three devices are connected to the secondaries of two transformers, the primaries of which are connected across the generator switch.

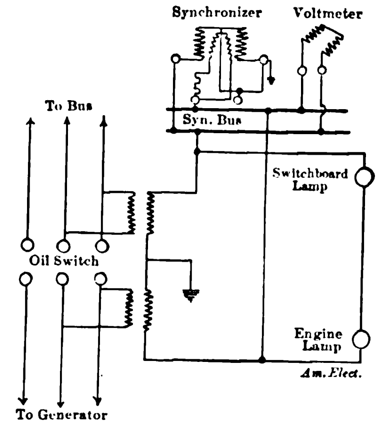


FIG. 5.—SYNCHRONIZER CONNECTIONS.

INTEGRATING WATTMETER CONNECTIONS.

BY ARTHUR B. WEEKS.

In spite of "how easy" it appears to connect even a single-phase wattmeter without a transformer, it frequently happens that one gets the connections reversed, and the disc will revolve from right to left, instead of in the opposite direction.

To connect a wattmeter while the motor is in operation, a jumper is necessary, and considerable caution is necessary to prevent either a short circuit or an open circuit. Before fastening the meter to the wall, connect the necessary wires to the meter. The size of wire used will depend upon the current passing per phase. On the wire *C* (Fig. 2) have an ordinary wire connector.

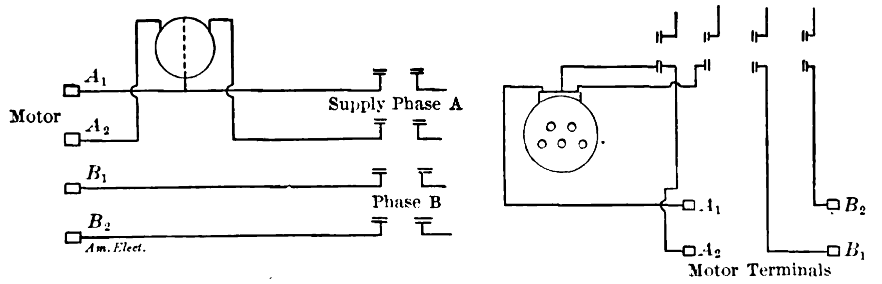


FIG. 1.—INTEGRATING WATTMETER CONNECTIONS.

Bare the wire at *x* and procure a jumper that will reach from *x* to A_2. With a connector on the jumper, fasten it at *x*, and place the other end between the back of the screw heads on the motor terminal, A_2, and make very secure. Remove the wire *B* from its terminal A_2 and screw it into the connector *C*. Then secure wire *D* into the terminal A_2. Next, make connections with the potential wire to A_1 terminal or to its lead, when if properly connected, the disc will revolve from left to right. Now remove the jumper, shown in dotted lines. Watch all wires, especially free ends. If doing the work unassisted, it is best to tape over free ends of the wires to protect one from shocks. To remove the wattmeter, reverse the operation already described.

The following will explain the calculations necessary to obtain the work done from the meter readings. The meter herein referred to is a standard Westinghouse single-phase meter, 400 volts and 40 amperes. It is guaranteed at 50 per cent overload. On the meter will be found this information: "1 division of 1000's dial equals 1000 watt-hours." Hence, after taking the reading, add three ciphers for the total watt-hours.

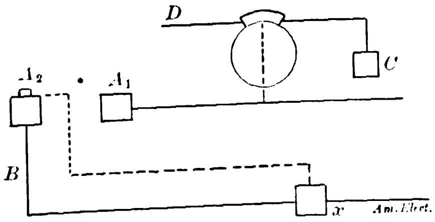


FIG. 2.—JUMPER CONNECTIONS.

In reading the dial, read the lower figure in each case. For instance, if the pointer is between 5 and 6, 5 is the number to place in the result. Follow this in each dial, and add three ciphers to the final result. As an illustration, at 9:10 readings were taken every ten minutes as follows:

34,664,000 — 9:10
34,669,000 — 9:20
34,674,000 — 9:30
34,680,000 — 9:40
34,686,000 — 9:50
34,691,000 — 10:00
34,698,000 — 10:10
34,704,000 — 10:20

10:20 — 9:10 = 1:10

34,704,000 — 34,664,000 = 40,000, the number of watt-hours for one hour and ten minutes.

40,000 × 3600 = 144,000,000.

One hour and ten minutes equals 70 minutes, or 4200 seconds.

144,000,000 ÷ 4200 = 34,286.

34,286 watts ÷ 746 = 46. This equals 46 horse-power per phase, or 92 horse-power for both phases.

If one reading had been left off, the operation would have been simpler. Thus:

34,698,000 — 34,664,000 = 34,000
34,000 ÷ 746 = 45.5
45.2 × 2 = 91 horse-power.

If the instantaneous value for 10 minutes is required, we have—

34,669,000 — 34,664,000 = 5,000 watt-hours.
3600 × 5000 equals 18,000,000.
10 minutes equals 600 seconds.
18,000,000 ÷ 600 equals 30,000 watts.
This result ÷ 746 equals 40.
40 × 2, the total horse-power load on the motor, equals 80.

Or, 30,000 watts ÷ 400, the voltage of the system, will give as a result the amperes of each phase.

Suppose the dial at 2:30 read 176,000
And 2 minutes later it read 177,000

Difference 1,000

1000 × 3600 equals 3,600,000.
2 minutes equals 120 seconds.
3,600,000 ÷ 120 equals 30,000.
30,000 watts ÷ 746 and × 2 equals 80 horse-power.

There is still another method of computing the horse-power, which is according to the number of revolutions made by the disc. For this particular instrument, the formula is as follows:

$$\frac{\left(\frac{R}{60} \times 40 \times 400 \times 1.2\right) \times 2}{746} = \text{total horse-power.}$$

For example, the disc makes 20 revolutions per minute.

$$\frac{20}{60} \times 40 \times 400 \times 1.2 = 6336 \times 2 = 12{,}672.$$

12,672 ÷ 746 = 17, or 17 horse-power.

The location of a meter is always an important item. They are delicate instruments and require delicate treatment. Do not install on vibrating walls. Do not locate where crowbars and missiles will fall against them. As soon as through with the meter, remove it and put it away in a safe place. It will be noticed by the connections on the diagram that the wires on the motor are in pairs; or that the wires for phase *A* are on one side, and on the other, the pair for phase *B*. The system employed for running the wires in pairs is as follows:

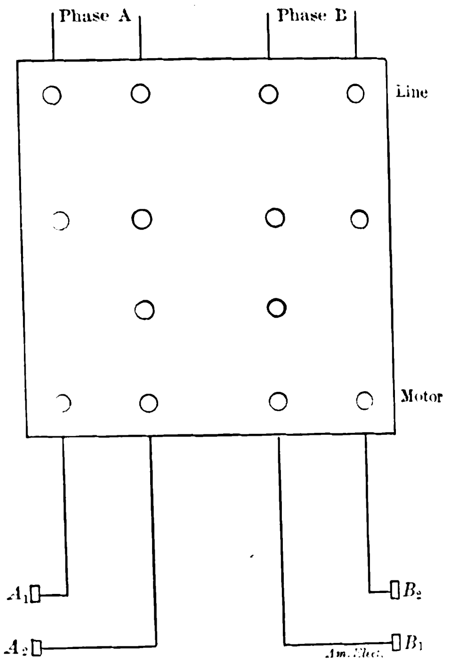


FIG. 3.—CONNECTIONS TO AUTO-STARTER.

Start from the switchboard to get them in this order, for they arrive at the switchboard from the generators in the following order: A_1, B_1, A_2, B_2. The wires are connected to the auto-starter in accordance to directions marked on the box. "The line and to the Motor."

The connections of the auto-starter are as shown in the following diagram:

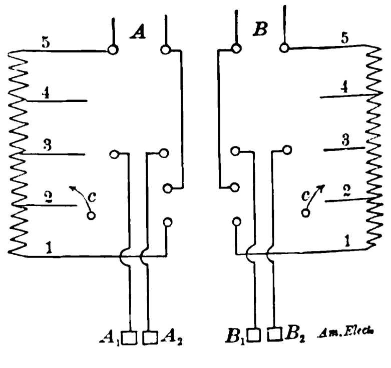


FIG. 4.—AUTO-STARTER CONNECTIONS.

For minimum starting torque, connect *C* to 2. The higher the number of the terminal to which *C* is connected, the greater the torque. Connect *C* of each phase to similar numbers.

Lessons in Practical Electricity

ARC LAMP REGULATING MECHANISMS.

As stated in the previous Lesson, one or both of the carbons of an arc lamp must be constantly adjusted as the tips burn away, in order to keep the length of the arc approximately constant. This adjustment is accomplished by means of electromagnets and suitable mechanism. There is also the operation of starting the arc to be done automatically. There are two generic types of arc-lamp mechanism, colloquially designated "shunt" and "series," the regulating magnets of which are connected respectively in shunt to and in series with the carbons. Fig. 1 represents diagrammatically the elements of a "shunt" lamp mechanism and Fig. 2 similarly represents a "series" lamp mechanism. The diagrams show the ordinary form of arc lamp in which the upper carbon is held in a socket at the lower end of a sliding rod or tube which is commonly but rather inaccurately designated "the carbon rod," and the lower carbon is held stationary in a socket attached to the lower part of the lamp frame. Both types of mechanism are used on constant-potential circuits.

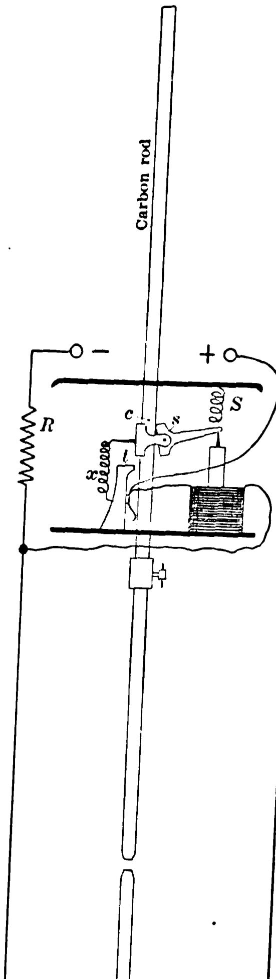


FIG. 1.

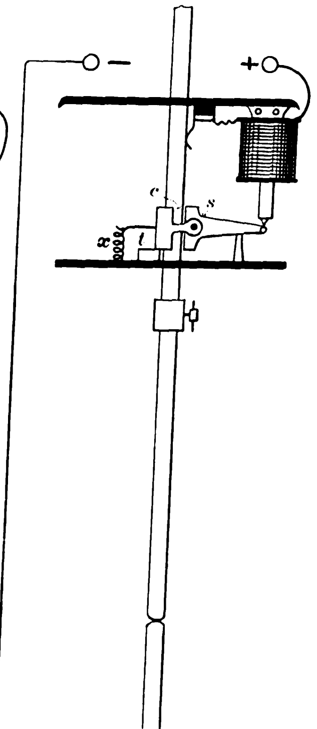


FIG. 2.

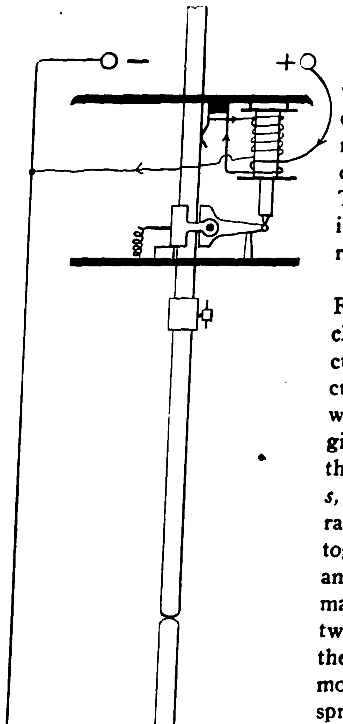


FIG. 3.

In the simple shunt type of lamp shown by Fig. 1, the upper carbon is held out of contact with the lower carbon by the spring, *S*, and the clutch, *c*, when the lamp is not in circuit. When it is connected to the circuit the current flows from the positive terminal (marked +) through the solenoid to the negative terminal. The solenoid, being thus energized, draws down the lever of the clutch shoe, *s*, allowing the light helical spring, *x*, to draw down the body of the clutch until it strikes the trip, *t*, which prevents the main part of the clutch from going any lower; the solenoid plunger continues downward, however, tilting the shoe, *s*, on its pivot until it releases the carbon rod and allows the upper carbon to drop on the end of the lower one. Current immediately passes through the two carbons, which short-circuit the solenoid and thereby enable the spring, *S*, to tilt the clutch shoe, *s*, into its gripping position and to raise the entire clutch and carbon rod. As the carbons separate, the shunt coil becomes energized again and restrains the spring, *S*, from pulling the carbons far enough apart to break the arc. A state of equilibrium is established when the arc is at its normal length, the springs, *S* and *x* being made adjustable for this purpose.

As the carbons burn away, the length of the arc is increased, thereby increasing the difference of potential across the carbons and consequently at the terminals of the solenoid winding, strengthening the solenoid and causing it to pull the clutch and carbon rod downward until equilibrium is again restored. This process, which is known as "feeding," continues until the clutch has been pulled down almost into contact with the tripping tongue, *t*. The next time that feeding becomes necessary by reason of the burning away of the carbons, the solenoid pulls the clutch downward until the body of it comes in contact with the trip, and as it cannot move any further downward the shoe, *s*, is tilted, releasing its grip on the carbon rod and allowing the latter to feed. The feeding process is intermittent, but both the time intervals and the feeding of the carbon are reduced to infinitesimal increments in a well-built lamp, the adjustment being so delicate that the solenoid restores the arc to its normal length before the carbons have burned away sufficiently to cause the increase in arc length to be noticeable.

The resistance coil, *R*, is necessary for two reasons: without it the e.m.f. at the terminals of the solenoid would be constant (the e.m.f. at the lamp terminals being constant) and no regulation would be possible. With the resistance coil in circuit, however, variations in the length of the arc cause corresponding variations in the difference of potential at the solenoid terminals. The resistance coil is also necessary for the purpose of steadying the arc. The resistance of an arc decreases with an increase of current, and it is, therefore, impossible to maintain a steady arc on a constant-potential circuit without inserting an appreciable resistance in series with the arc. The resistance of ordinary conducting materials increases as their temperature increases; consequently, an increase in current through the resistance coil, *R*, will cause its resistance to increase slightly. This tends to compensate for the decrease in the resistance of the arc when the current increases, and *vice versa*.

In the series type of lamp represented by Fig. 2, the carbons are in contact and the clutch is free when the lamp is out of circuit. As soon as the lamp is thrown in circuit, current passes through the solenoid winding and the carbons in series, energizing the solenoid and causing it to jerk the clutch lever upward, pulling the shoe, *s*, into its gripping position, and through it raising the entire clutch and carbon rod together until the arc attains normal length and reduces the rush of current to its normal value, when equilibrium is attained between the upward pull of the solenoid and the downward pull due to the weight of the moving parts and the tension of the small spring, *x*. This lamp is used only on constant-potential circuits, and the current passing through the lamp depends solely upon the resistance of the lamp circuit. Consequently, as the carbons burn away and the arc lengthens, increasing its resistance, the current decreases, weakening the solenoid and allowing the carbon rod to feed downward until equilibrium is again established. This continues at small intervals until the clutch is almost in contact with the tripping block, after which the feeding is accomplished by the release of the grip of the clutch on the carbon rod, as in the case of the shunt lamp. If the voltage of the circuit on which the lamp is used is greater than the voltage required by the arc and the solenoid, resistance coils are put in series, of course, in order to reduce the voltage between the positive terminal of the solenoid and the negative carbon to the proper amount. But since the solenoid winding has some resistance, an additional resistance coil is not usually necessary solely for the purpose of steadying the arc.

When arc lamps are to be operated on constant-current circuits, neither of the types of regulating mechanism just described is suitable. If the dynamo supplying current to the circuit were separately excited, so that its field-magnet strength would be independent of the current flowing in the circuit, simple shunt lamps could be used; but the separate excitation of direct-current dynamos is needlessly expensive in the present state of the industry. The arc lamps connected in series on a constant-current circuit, therefore, are provided with a regulating mechanism which is substantially a combination of the two types already described. Fig. 3 illustrates one form of this type of lamp, which is known as the "differential" lamp. Comparison of this diagram with Fig. 2 will show that the only fundamental difference between the two lamps consists of the addition of a shunt winding on the solenoid bobbin, this winding being connected so as to oppose the series winding.

When no current is on the lamp the carbons are in contact, as shown in the sketch. As soon as current passes through the lamp the solenoid is energized by means of its series winding and picks up the carbon rod, forming the arc between the two carbons, as in the case of the simple series lamp. When the carbons have been separated to the normal distance the current through the shunt winding of the solenoid will have increased to such a value as to neutralize the series winding sufficiently to produce a state of equilibrium. As the carbons burn away, the shunt winding becomes stronger, so that the *resultant* magnetic force exerted by the two windings is decreased, allowing the carbon rod to feed downward until the arc becomes normal. The series winding is at all times stronger than the shunt winding, the latter only partially neutralizing the former.

Another form of differential lamp is in common use, in which the series and shunt windings are entirely separate and arranged to pull the clutch in opposite directions. This arrangement is illustrated in Fig. 4. The two solenoid windings have a common iron core to which is pivoted the clutch lever. The series winding pulls the clutch and carbon rod upward and strikes the arc, and the subsequent feeding is accomplished by the opposing pull of the shunt solenoid. This lamp is suitable also for use on constant-potential circuits, and is used to a great extent where two or more lamps are operated in series on such circuits. The simple shunt lamp shown by Fig. 1, however, is also operated in series groups on a constant-potential circuit with entire satisfaction. The simple series lamp shown by Fig. 2 is the only one which cannot be operated satisfactorily in series with other lamps; it is only suitable for use singly on constant-potential circuits.

As the carbons of an ordinary arc lamp burn away, the location of the arc is, of course, lowered gradually, because the lower carbon burns away as well as the upper one. In some special forms of arc lamp it is desirable to keep the arc fixed in one place, and in such lamps both the upper carbon and the lower are mounted in sliding holders so that the lower carbon may be fed upward, while the upper one is fed downward and the arc thus maintained at the same point as in starting. In order to secure precision in the respective rates of feeding, the two carbon holders are usually geared together, as indicated by Fig. 5. The upper carbon rod, if round, is provided with a rack on one side which meshes with one of two gear wheels mounted on a single spindle. The other gear wheel, which is of approximately one-half the diameter of the first one, meshes with a rack the lower end of which carries the holder of the lower carbon. Magnets or solenoids are adapted to control the motion of the gear wheel. This arrangement causes the upper carbon to feed downward at about twice the rate that the lower one feeds upward, which is necessary in the class of lamps under discussion, because of the fact that the upper carbon wastes away about twice as rapidly as the lower one.

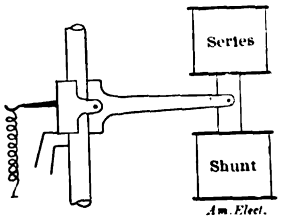


FIG. 4.

In the ordinary form of arc lamp, in which only the upper carbon is fed, a rack and gear mechanism is also used sometimes. The wheel which meshes with the rack on the carbon rod is usually mounted in a pivoted frame and geared to an escapement, which regulates the rate at which the carbon rod can feed downward when the gearing is unrestrained otherwise. The pivoted frame in which the gears are mounted is moved upward or downward, according to the requirements, by magnets and springs exactly as the clutch lever in the types of lamps here illustrated is moved upward and downward. When the frame is drawn upward the escapement is pulled into contact with a pawl, which prevents its oscillation and thus locks the carbon rod to the pivoted frame. The clutch type of lamp, however, is mostly used for ordinary classes of service.

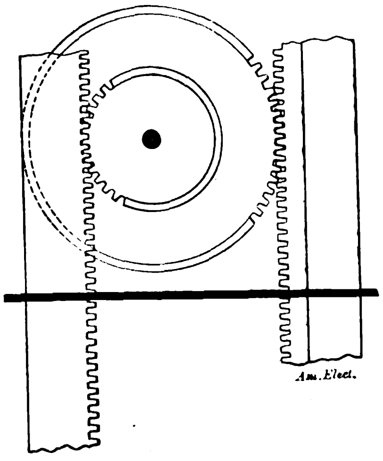


FIG. 5.

In lamps operated on alternating-current circuits the two carbons are of the same length and the rate at which they are consumed is approximately the same for both; consequently, when it is desired to keep the arc in one spot the two racks mesh with the same gear wheel and feed at the same rate. Alternating-current arcs and arc lamps will be discussed more fully after the fundamental principles of alternating currents have been explained.

Letters on Practical Subjects

Ratio of Kilowatts to Horse-Power.

To the Editor, American Electrician:

It may be interesting to some of the readers of the American Electrician to know that the ratio of a kilowatt to a horse-power is as 63 is to 47, very nearly; and if two scales of a slide rule be set with these numbers coinciding, say, 63 on the *C* scale opposite 47 on the *D* scale, then any number on the *C* scale may be considered horse-power, and opposite it on the *D* scale will be found its equivalent in kilowatts.

Robert M. Lee.

Washington, D. C.

Alternator Regulation.

To the Editor, American Electrician:

In the department of "Queries and Answers" in the October (1902) number, the answer to an inquiry for a method of testing regulation of alternators included the following formula:

$$100 \times \frac{E \quad \frac{e\,S}{s}}{E} = \text{per cent of regulation,}$$

in which E is the e.m.f. at no load, e the e.m.f. at full load, S the speed at no load, and s the speed at full load. There appears to be something wrong with this formula, as the two E's cancel each other, reducing the formula virtually to

$$100 \times \frac{e\,S}{s} = \text{per cent of regulation,}$$

and eliminating the no-load voltage entirely. As a correct formula for alternator regulation would be very useful, I take the liberty of calling attention to what seems to be an error in the present formula and suggesting that a corrected formula be given.

B. C. Wilson.

Coplay, Pa.

[There is, indeed, "something wrong" with the formula as it appeared. The formula was intended to read:

$$100 \times \frac{E - \frac{e\,S}{s}}{E} = \text{per cent of regulation,}$$

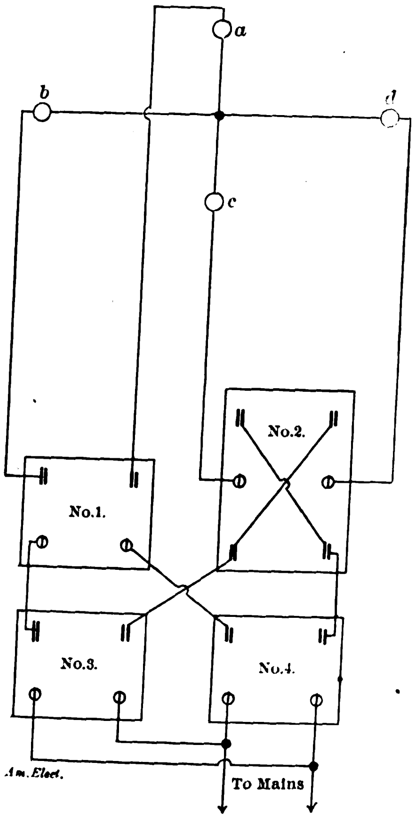
but with customary mathematical recklessness the printer consolidated the minus sign and the small fraction dash in the numerator. Mr. Wilson has our thanks for calling attention to the error, and we shall be very glad to have other readers point out any errors that they may discover in the reading columns of the paper.—EDITOR.]

◆

Another Solution of Mr. Lohman's Problem.

To the Editor, American Electrician:

I submit herewith a second solution of Mr. Lohman's problem, which avoids the objection of short-circuiting the line and



MR. POOL'S SOLUTION.

also avoids burning out any of the lamps. To light all the lamps, all switches must be closed; if No. 2 is closed upward, opening No. 3 leaves *a* and *c* lighted; opening No. 4 leaves *b* and *d* lighted; opening No. 2 leaves *a* and *b* lighted; opening No. 1 leaves *c* and *d* lighted. If No. 2 is closed downward, opening No. 3 leaves *a* and *d* lighted; opening No. 4 leaves *b* and *c* lighted. Opening any two of the switches puts out all the lamps; that is, at least three switches must be closed before any of the lamps will light.

C. H. POOL.

New York.

◆

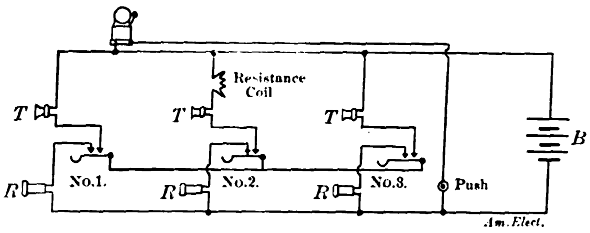
Common Battery Telephone Systems.

To the Editor, American Electrician:

In the November AMERICAN ELECTRICIAN Mr. A. Dallam O'Brien describes a system of intercommunicating telephones in which one battery and one pair of leads from same operates both the call bells and telephone circuits, with a resistance introduced at each of the battery leads. By making some slight changes in connections, I find improved results can be secured, requiring only half the number of cells and less frequent attention; the arrangement is shown by the accompanying diagram. As no resistance is inserted in the battery line, three cells of battery will answer in most cases, excepting where great distances are encountered, in which case one or more cells will need to be added; in any case only the usual number required for ordinary bell work will be required. An additional common wire must be run with a tap for each instrument, and an additional contact at the hook switch must be arranged so that contact is made when the receiver is removed. This places the receivers and transmitters of the sets that are in use in series-multiple, thereby reducing the resistance of the talking circuit and at the same time greatly increasing the sensitiveness of the transmitters. No changes are made in the bell wiring; where the bell is secured to the instrument, connection can be taken directly from either battery wire, the opposite wire of course being connected to the pushes. Where the telephones are much used, or the distances require a greater number of battery cells to ring the bells properly, a resistance coil of about four ohms can be inserted between the battery wire and transmitter of each instrument, as shown at station No. 2, thus protecting the transmitters against excessive heating and prolonging the life of the battery.

Strictly speaking, the system as shown is not a commercial intercommunicating system, since only one talking circuit is provided. In many cases, however, this simplified system is preferable on account of the small cost, easy operation and reduced liability to derangement. To make the diagram clearer, only one push and bell are shown; but for an intercommunicating system of, say three stations, one bell and two pushes will be required at each station, and where only certain calls are desired the bell work can be arranged accordingly, as frequently some of the stations require no calling facilities. When a system permitting the use of all the stations at the same time is necessary, the same talking circuit of two battery wires and one line wire can, by the addition of a selective switch and the necessary changes in the hook switch contacts, be arranged for such service, and will give splendid results, the absence of inductive devices greatly decreasing the annoyance of cross-talk.

St. Louis, Mo. CHAS. J. SUTTER.



COMMON BATTERY TELEPHONE SYSTEM.

Electrical Catechism

725. *What is Thums' process for the electrodeposition of platinum?*

This process has been carried on for some time by the Platinum Plating Company, and, it is claimed, gives a deposit which is so bright that it requires no subsequent polishing. In the preparation of the bath, a solution of chloride of platinum is made in the usual way, which is subsequently rendered neutral by any ordinary method. To this solution of platinum is added a weak solution of common phosphate of soda, to which is next added a weak solution of phosphate of ammonia, and the whole is then boiled for several hours, during which operation a solution of chloride of sodium is added. The proportions of the above ingredients, which are recommended, are as follows: Platinum chloride, 1 ounce; sodium phosphate, 20 ounces; ammonium phosphate, 4 ounces; sodium chloride, 1 ounce. The solution may be worked at any suitable temperature, but it is preferable to work it warm. Strong current must be employed and the cathode should be kept in motion while the deposition of platinum is going on.

726. *How can cobalt be deposited electrolytically?*

Cobalt is a strong and serviceable coating for metals, more especially for brass, copper and steel, since it is not only whiter than nickel when deposited under favorable conditions, but it also requires a very feeble current for its deposition, as compared with that required for the former metal. While it is true that cobalt is more expensive than nickel, still the cobalt bath requires only about one-third of the quantity of salts required to make up a nickel bath, so that the actual cost of the electrolyte in each case would be about the same. One of the difficulties which militate against the adoption of cobalt plating for practical purposes is the inability to obtain anodes of cobalt and reliable cobalt salts. Prof. Silvanus Thompson patented a process for depositing cobalt, the solution consisting of sulphate or chloride of cobalt, and the double sulphate or chloride of magnesium, or other suitable soluble salts of magnesium, or a mixed soluble salt of magnesium and ammonium may be added to the cobalt salts. The bath is prepared by adding to 10 pounds of distilled water one pound of the double sulphate of cobalt and ammonium, ½ pound of magnesium sulphate, ½ pound of ammonium sulphate, 1 ounce of citric acid and 2 ounces of ammonium carbonate. The solution may be used either warm or cold, but if heated to a temperature of 95° Fahr., the bath gives a brilliant deposition with greater readiness than if used cold. Prof. Thompson found that the best current density to be used with the bath should be not less than one ampere, nor more than 4 amperes, per square foot of depositing surface.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Where can I obtain round Norway iron 2½ inches in diameter? J. H. J. B.

From any large dealer in iron and steel. Try Ogden & Wallace, this city.

What size of spark coil will be needed for signalling by wireless telegraphy over a distance of two miles? I have used a half inch spark without success. F. G. M.

At least a two-inch, and preferably a three-inch, spark will be required for satisfactory results.

How can I figure the size of wire necessary for a tunnel line 7,400 feet long, carrying 74 16-c.p. lamps located 100 feet apart, the line to be three-wire, the bus-bar e.m.f. 240 volts, and the maximum drop not over 20 per cent? C. T.

Calculate the line as though it were 3700 ft. long, carrying one-half the total number of lamps, with a drop of 10 volts.

How can the voltmeter described in "Electrical Designs" be made "dead beat?" (2) Please give instructions for making an alternating-current voltmeter and ammeter like the inclined-coil instruments of the General Electric Company. J. A. B.

It cannot be made "dead beat" without impairing its accuracy seriously. (2) We do not supply data for the duplication of any commercial apparatus.

Will a hollow magnet core, such as a piece of iron pipe, be as strongly magnetized through the center as in the iron shell? (2) Would it behave like a solenoid and attract a soft iron plunger inserted in the pipe? G. M.

Assuming that you mean by the "center" the central column of air, no. (2) Not unless the magnetizing coil is so powerful as to fully saturate the iron of the tubular core and produce a strong field inside of it in addition.

A 40-kw. dynamo driven by a 50-h.p. gasoline engine, operating in parallel with a 25-kw. machine driven by a 40-h.p. gasoline engine, will not divide the load properly. The ammeters show that first one and then the other of the two machines takes nearly all of the load. What is the trouble? G. F.

Your gasoline engines do not govern closely enough to justify parallel operation. From your remarks it would seem that the engine governors are of the hit-and-miss type.

In a four-wire three-phase system, does the common return wire need to be of the same size as each of the three main wires? (2) What is the ratio of the current in the common return wire to the current in one of the main wires? H. H. P.

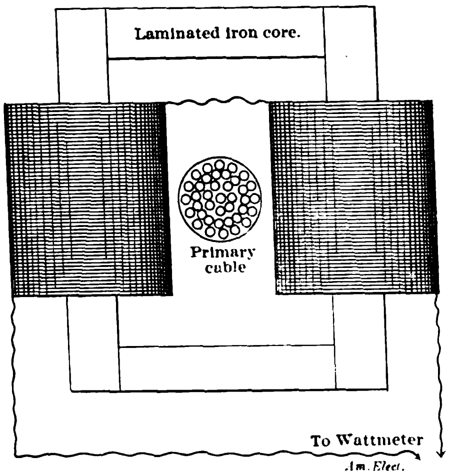
Not necessarily, although in high-tension transmission lines it is usually made of the same size so as to be available for full-load current in an emergency. (2) This depends upon operating conditions. When the system is balanced there is no current in the fourth or neutral wire; the amount of current flowing in it depends upon the extent of unbalancing, exactly as in the case of the neutral wire of a three-wire direct-current system.

If a brass ball be located between the two terminal balls or knobs of a six-inch spark coil and connected to the middle of the secondary winding, what would be the result? (2) If two induction coils be connected in parallel and a single interrupter be inserted in the combined primary circuit of the two, will the combined secondary terminals give twice the current volume of a single coil? N. J.

You would obtain two sparks of the shorter length and the strain on the insulation of the secondary would be reduced. (2) Yes.

Will a 30-cycle three-phase motor work on a 60-cycle three-phase circuit of the same voltage? (2) The accompanying sketch shows a current transformer for an alternating-current wattmeter, the cable through the center carrying the main line current and serving as the primary of the wattmeter transformer. As the intensity of a magnetic field about a wire varies inversely with the distance from the wire, will not a variation in the size of the cable cause a variation in the flux in the iron core? M. V. W.

Yes, but the speed will be doubled and the magnetic flux will be halved, thus reducing the torque of the motor. (2) The magnetic strength about a conductor varies inversely as the distance from the *center* of the conductor and that only when the medium surrounding the conductor is of uniform permeability, as when a wire is suspended in air. In the case cited changing the size of the cable would have no effect upon the flux in the iron core.



Figs. 67 and 87 in "Electrical Designs" show different arrangements of armature windings. I have always been taught that the arrangement of Fig. 67 is not good and that the arrangement of Fig. 87 is a practical winding. If this is true, why are both arrangements used? L. M. S.

Fig. 67 shows the arrangement of a lap winding and Fig. 87 shows the arrangement of a wave-connected winding. Both are correct for the respective classes of windings. Fig. 67 could not be used for a wave winding, nor could Fig. 87 be used for a simple lap winding.

When the field of a dynamo running in parallel with another dynamo is weakened preparatory to throwing the machine out of circuit, why does not the decrease in its e.m.f. allow the other machine to send current backwards through the dynamo that is to be taken out of circuit? F. S.

Because the voltage actually generated by the armature is never lowered below the bus-bar voltage, but is only brought down to a point nearly equal to the bus-bar voltage. When the machine is running normally the total e.m.f. of the armature is considerably higher than that at the bus-bars, this being necessary in order to overcome the resistance of the armature winding and the circuit connections between the armature and the bus-bars.

If a small bipolar direct-current motor with a laminated field-magnet be separately excited and alternating current be supplied to the armature through two collector rings connected at opposite points of the winding, will the machine operate as a synchronous motor on a 60-cycle circuit after being brought up to speed? (2) With the motor arranged as described, but not connected to an alternating-current circuit, would the machine deliver both direct and alternating currents if driven at the proper speed from an appropriate source of power? (3) Could a core of soft annealed iron wire be substituted for the No. 27 transformer iron specified for the core of the 200-volt transformer described in "Electrical Designs?" If so, what size of wire should be used? C. M. H.

Yes. (2) Yes; the machine can also be used as a rotary converter, operating as a synchronous motor on an alternating-current circuit and delivering direct current at the commutator. (3) Yes; use wire of the same gauge as the sheet iron specified.

Having two sets of three transformers each connected in delta on a three-phase circuit and in multiple with each other, if one transformer of one of the two sets should burn out what would be the result of disconnecting the damaged transformer and leaving the other two of that set connected in multiple with the other set of three transformers? B. H. E.

The result would be the same as though you connected two transformers of a given size with a third transformer of half the size, the three being connected delta. Either the small transformer would be heavily overloaded or the large ones would be underloaded. The two transformers could be operated alone by overloading them 70 per cent, but if they are connected in multiple with two of the group of three, the third transformer of the complete group would be overloaded about 100 per cent when the others were working at normal load.

How can I ascertain the commercial efficiency of a motor? (2) What is the proper angle at which to set the brushes of a six-pole motor with a two-path armature winding? (3) With the brushes of the machine just mentioned set 60 degrees apart, there is considerable flashing when the motor is reversed; why is this? C. F. A.

If the accurate full-load current is known (it can usually be obtained from the manufacturer) the commercial efficiency of the machine may be calculated by means of the formula,

$$100 \times \frac{746 \times \text{h.p.}}{E \times (I + i)} = \text{per cent eff.},$$

in which *h.p.* is the brake horse-power of the machine at full load, E is the e.m.f. at its terminals, I is the full-load armature current, and i is the current in the shunt field winding. If the full-load armature current of the machine is not accurately known, it can be ascertained by the method described on page 501 of the October (1901) number of this paper. (2 and 3). The brushes of a two-path six-pole motor should preferably be set diametrically opposite each other in order to reduce the liability to flashing over. This flashing is due primarily to the fact that the number of commutator segments is too small.

AUTOMATIC TELEPHONE SYSTEM.

That the manual system of telephony is prolific of many petty annoyances and delays, every user of the telephone is aware. That these imperfections will ever be eliminated in manual practice not even the most sanguine will allow, since the human element is too large a factor in telephonic manipulation. If means were provided whereby the speaker himself could make the connection, ascertain directly whether the line were busy or not, carry on his conversation, and disconnect when through, it is evident that many of the annoyances now suffered would be like tales that are told. This is just the office of the automatic telephone; to automatically and instantaneously connect the subscriber with the person desired and give them a line over which to talk.

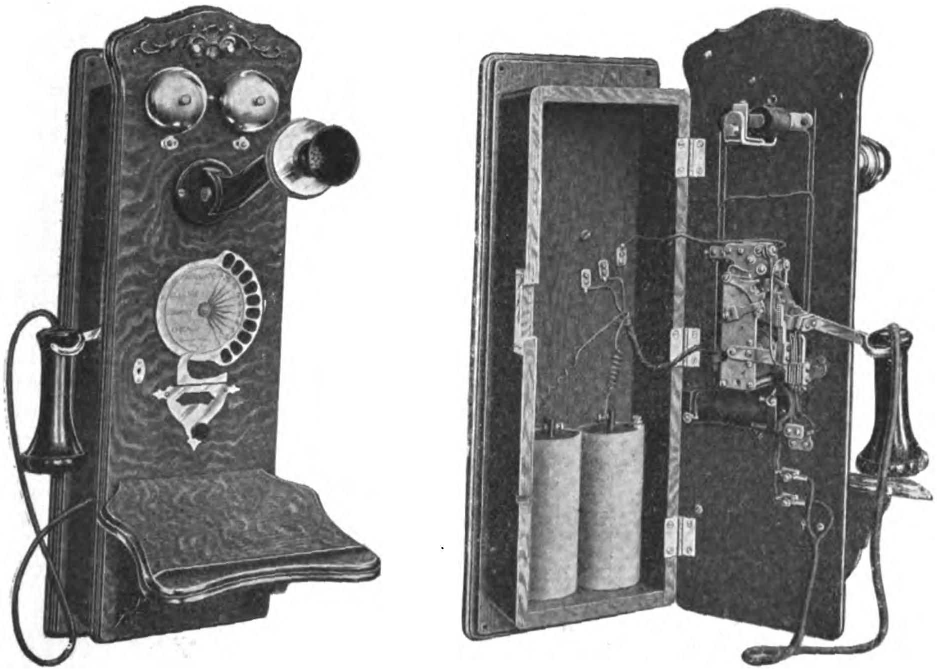


FIG. 1.—FRONT AND INTERIOR VIEWS OF WALL TELEPHONE.—FIG. 2.

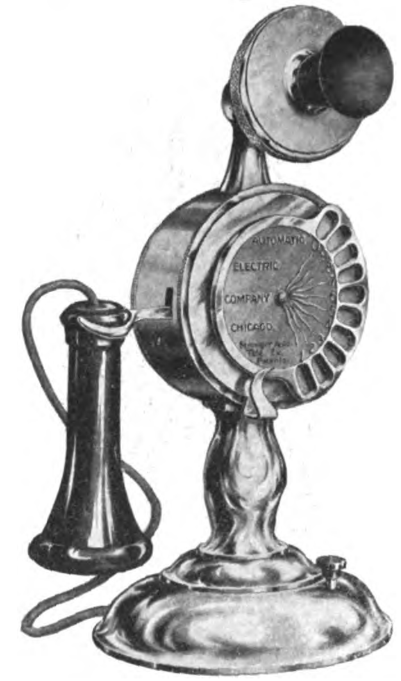


FIG. 4.—DESK TELEPHONE.

The accompanying illustrations show various parts of an automatic telephone system controlled by the Automatic Electric Company, of Chicago. As will be seen the telephone consists of the usual transmitter, receiver, bells, battery and induction coil. with the addition of the selector calling apparatus occupying a small space just above the battery. On the front of the box is the metal calling dial, on the right side of which and along the edges are ten finger holes numbered consecutively from 1 to 0. A stop is provided at the lowest of the holes to limit the distance to which the dial may be revolved when the finger is inserted. This keyboard and dial are shown more clearly by Fig. 3. To call a number, say 761, the subscriber first takes the receiver from the hook, then placing his finger in the hole No. 7 turns it around until the finger comes against the stop mentioned; releasing the finger restores the dial instantaneously to its original position through the action of a spring. The subscriber is now connected to a trunk line leading to a group of switches which, in this case, may be called the seventh hundred group. In the same manner Nos. 6 and 1 are called in this group. Having turned the numbers desired, a button is then pressed which rings the bell of the person wanted and the connection is completed. One second or less for each decimal is all the time required. In the event that the desired subscriber is busy, a buzzing sound in the receiver notifies the caller that such is the case.

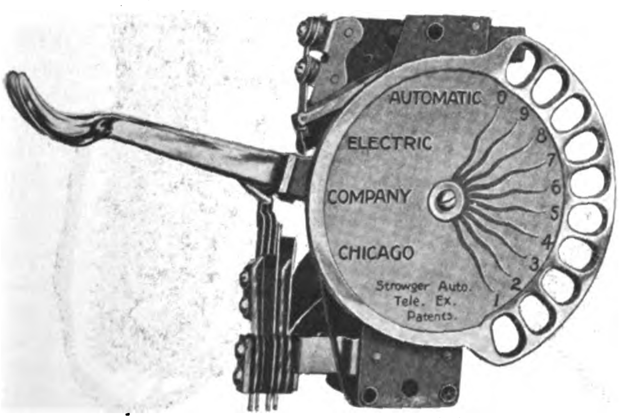


FIG. 3.—KEYBOARD AND DIAL.

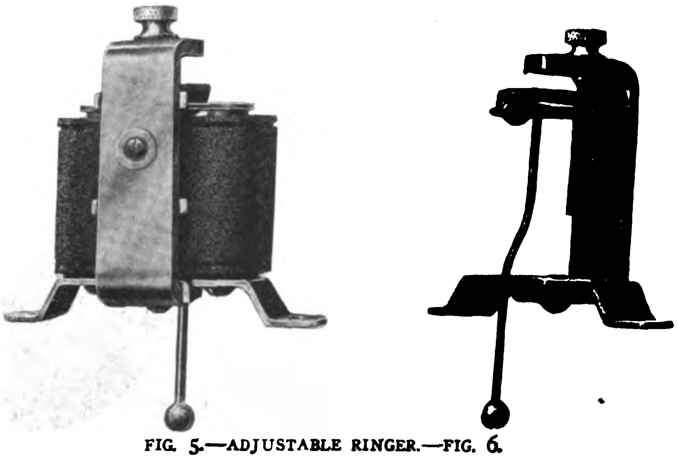


FIG. 5.—ADJUSTABLE RINGER.—FIG. 6.

Fig. 1 shows the standard wall telephone which is 22 ins. high, 7½ ins. wide and 5 ins. deep, and Fig. 2 shows the interior of the telephone with the receiver on the hook. The ringer, dry cells, induction coil and calling mechanism make up the contents of the telephone set, and their position and relative size are clearly shown in the engraving. All the springs are made of German silver and platinum rivets are used instead of soldered contacts. The desk telephone is shown by Fig. 4. In this the case and pedestal are of nickeled drawn brass, the front and rear caps of the case being removable, so that the calling mechanism may be easily and quickly inspected without disconnecting a wire. The induction coil is mounted in the base of the pedestal, and the calling device, though somewhat different in shape, is similar to that of the wall telephone.

In the transmitter, instead of the usual narrow bridge or solid back holding the back carbon, a cup made of steel is used. The front cap is of brass, and the arm is made of two pieces of steel; the base is also of steel. In assembling the instrument the metal diaphragm is placed in the cup; the back cup is then screwed into the cap, after which the arm is screwed into the cap covering the cup. This makes a simple transmitter and one easily repaired. The receiver is of the usual double-pole type, with concealed terminals. The induction coil is made of No. 20 soft Norway iron,

⅜ in. thick. The primary is wound to 1-5 ohm with No. 19 single cotton covered wire, and the secondary is wound to 50 ohms with No. 29 single silk covered magnet wire. After being made up the magnet is dipped in beeswax.

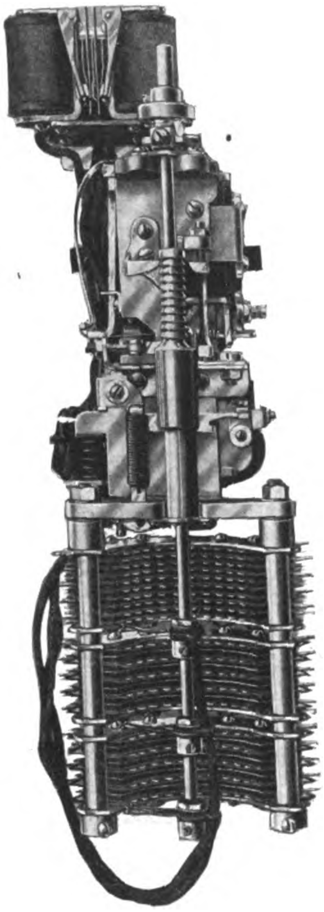


FIG. 7.—FRONT VIEW OF SWITCH.

The ringer which is used exclusively, is shown by Figs. 5 and 6. As may be seen from the illustrations, the adjustment of the ringer is very simple. The armature is moved to or from the coils by loosening the screw in the center of the permanent magnet which secures the movable back on which the armature is mounted, so that by turning the set screw at the end of the permanent magnet, the armature can be quickly adjusted.

Front, side and rear views of the switch, which is the vital part of the system, are shown by Figs. 7, 8 and 9. This automatic device is 13 ins. high, 4½ ins. deep and 4 ins. wide. The upper half is made up of six relays, two main line and four local, which operate the selective parts of the lower half. The latter consists of three sets of banks of one hundred contacts each, one busy and two line banks arranged in ten rows of ten contacts each mounted on a semicircular structure, the axis of which is a vertical rod about the size of a lead pencil, upon which is fixed a short contact arm about 1½ ins. long.

The rod has both a vertical and a rotary motion, each controlled by one of the magnets mentioned. If the subscriber call 76, for instance, the rod is lifted vertically by the first movement of the subscriber's dial, which sends a current over one side of the two-wire circuit, thus raising the rod step by step to the seventh row of contacts. The second movement of the subscriber's dial sends the current over the other side of the circuit, and the controlling magnet gives the rotary motion to the rod which moves the contact arm to the sixth contact in the seventh row, thus securing the connection with 76. When the receiver is replaced, current is sent over both wires of the circuit, releasing the selector rod which goes back to its original position.

The lower part of each switch, as stated, consists of three banks of contacts, the one mounted over the other, and held in place and secured to the superstructure of the switch by two rods of Bessemer steel, which pass through the steel binding plates at the top and bottom of each bank, and are fastened by four nuts. The top bank is the "busy" bank, and consists of one hundred spring brass contacts, arranged in ten rows of ten contacts each, bound and held together by two steel plates. The insulation used consists of bond paper, treated with linseed oil, with a fiber filling. The vertical and rotary banks are similar in structure and are well illustrated by the one shown by Fig. 10. The one hundred contacts are arranged in five rows of twenty contacts to the row. Each row consists of two layers of contacts, ten to the layer, as shown by Fig. 11, the layers being separated by an insulated strip of fine fiber and linseed oil paper. All banks are wired with No. 24—one cotton and two silk—beeswaxed and tinned switchboard wire. The vertical and rotary bank wires are twisted in pairs throughout the system.

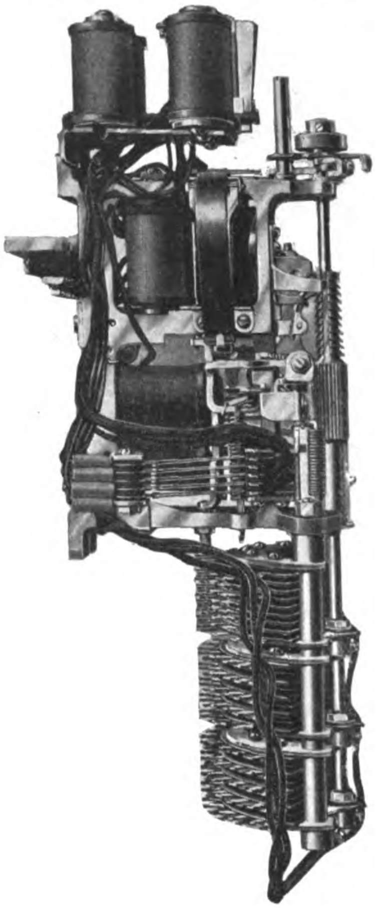


FIG. 8.—SIDE VIEW OF SWITCH.

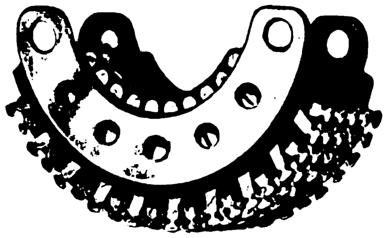


FIG. 10.—ROTARY BANK.

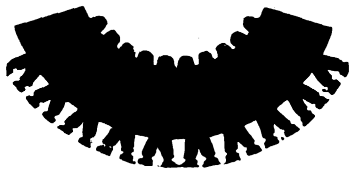


FIG. 11.—ARRANGEMENT OF CONTACTS.

In describing the switch and its operation, we have incidentally explained the operation of an exchange of 100 or less subscribers. In a system of 100 to 1,000 subscribers the trunking feature is introduced. Ten trunk lines have been found sufficient to do the business of each 100 subscribers, but any percentage can be given. A board equipped for 1000 subscribers would, therefore, have 1000 selector switches and 100 connector switches or 100 pairs of cords, unless a greater percentage of connectors should be required. The connector switches are arranged in ten groups of ten switches each, and each group is capable of connecting to 100 subscribers; the first group connecting subscribers whose numbers are between 100 and 200, the second group connecting those between 200 and 300, and so on. In calling, the first movement of the dial would pick out one of the ten trunk lines leading to the hundreds group de-

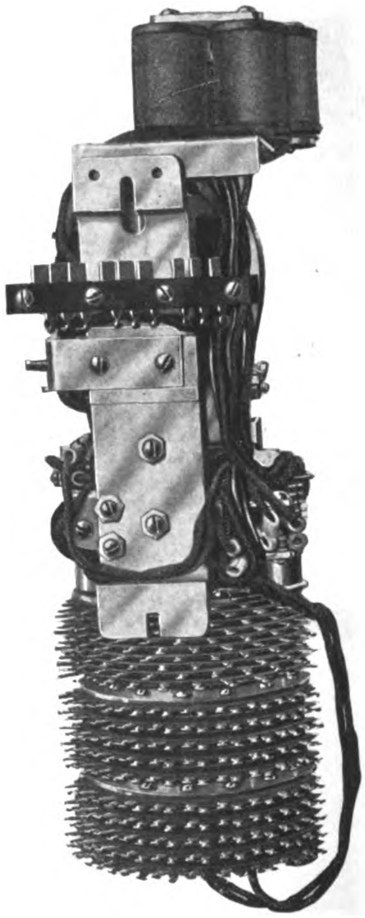


FIG. 9.—REAR VIEW OF SWITCH.

sired. The next two movements would connect with the desired number in that group. To illustrate, we will say that No. 761 is wanted. No. 7 on the dial being revolved, the subscriber is automatically connected with one of the ten trunk lines leading into the seventh group of hundreds. The next two movements, Nos. 6 and 1, select the No. 61 in that group, and he is immediately connected with the desired number. The apparatus automatically selects the lines which are not busy. If the first trunk line is engaged, the connecting arm passes over it and selects the second; that being engaged also it selects the third, and so on until a disengaged line is found.

The method of operating an exchange of from one to ten thousand is simply an extension of the trunking system. In a 10,000 subscriber exchange there would be 10,000 first selectors, 2,660 second selectors and 1,500 connectors. The subscriber wanting to get No. 7654 would, therefore, by the first movement of the dial, automatically select one of the trunk lines of the 7000 group; the second movement would put him in the seventy-sixth group of hundreds; the last two movements would select the party desired, and give him the connection.

Metallic circuits are required in the operation of the automatic telephone. Two lines run from the exchange to each subscriber's station, one of which may be called the "vertical" and the other the "rotary" line, the former controlling, through a relay, the vertical step-by-step movement of the contact arm of the switch, the latter the rotary movement. These lines are normally closed on the main battery at the central station. The subscriber, by the first movement of his dial, opens and closes his vertical line the required number of times, which "steps up" the contact arm the same number of points. The second movement on the dial opens and closes his rotary line the desired number of times, which rotates the contact arm the corresponding number of points, and, if the line desired is not engaged, gives him the connection he wishes. Should this line be busy, a relay throws an interrupted battery current on the subscriber's line, which gives him the busy signal.

The communication circuit includes the subscribers' instruments and the line relay magnets at the central station, and is bridged by two high retardation coils, having a battery and ground connection. The subscriber having connected with the desired line presses a button which gives him a ground connection and energizes one of the line relays which then connects the bell-ringing generator at central with the circuit and rings the bell of the subscriber wanted. The hanging up of the receiver energizes all of the relay magnets simultaneously, releasing the contact arm and its support, which drop back to the normal position. In the event that the subscriber is working in an exchange where the trunking system is used, first the thousands trunk lines and then the hundreds are automatically selected on the vertical line, and then the connection is secured with the tens and units as described.

THE NEW WESTINGHOUSE GAS ENGINE.

The Westinghouse Machine Company, whose three-cylinder, vertical, single-acting gas engine is well known, has been for some time engaged in developing the double-acting type of engine, and has now perfected this type in powers ranging as high as 3,000 horse-power. Fig. 1 shows a perspective view of a single-crank engine of the new type and Fig. 2 that of a double-crank engine. Fig. 3 shows the general design of the single-crank engine, which is shown direct connected to an electric generator. It is quite apparent that the engine resembles a modern high-speed tandem compound steam engine in the arrangement of cylinders, frames, bed plates, bearings, flywheel and generator. This resemblance is further carried out in the matter of crank effort. In each revolution there are two impulses, one occurring at each successive in-stroke and out-stroke. The engine operates, therefore, upon the four-stroke cycle, which gives distinct periods of admission, compression, explosion and expansion, and exhaust.

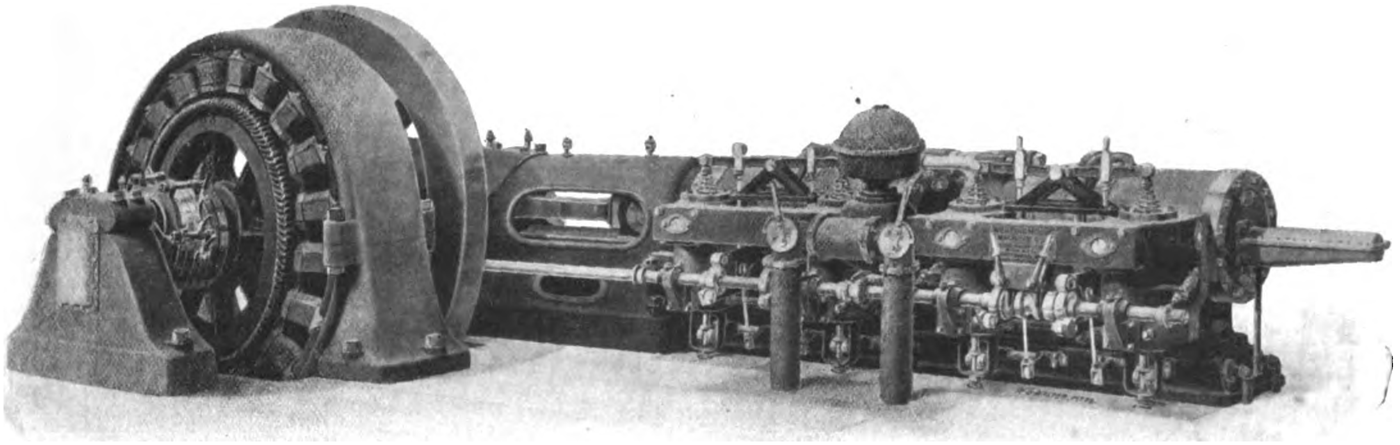


FIG. 1.—SINGLE-CRANK WESTINGHOUSE GAS-ENGINE.

The employment of the four-stroke cycle makes available a feature of importance, that of positive scavenging. In all engines employing the two-stroke cycle, scavenging must be accomplished either by a special piston movement or by a blast of air from an auxiliary pump, directed in such a manner as to force out the remaining burned gases. This latter method obviously entails a dilution of the incoming mixture, and variations in the calorific value of the explosive mixture, which, for a gas of given analysis, should be maintained constant. The engine here illustrated scavenges upon the return stroke of the pistons, which then draw in their charge of explosive mixture, practically undiluted either by products of combustion or by scavenging air. The new Westinghouse engine takes a mixture of unvarying quality, which is initially proportioned according to the nature of the gas used, and remains constant under all conditions of load. As the load increases or decreases, a correspondingly greater or lesser quantity of mixture is admitted to the cylinders.

In construction the engine departs materially from the accepted European design and embodies many established features of modern steam engine practice. From crank to cylinders, the construction is that of a horizontal steam engine suitably strengthened in proportion to the increased maximum pressure due to the explosions of the charge. The design of cylinders, pistons and valves, of course, departs materially from steam engine practice. The cylinders are double-walled, with the outer walls split peripherally to permit independent expansion and contraction without placing the cylinder casting under stress. The two cylinders are united at the top by heavy tie rods, engaging peripheral bosses, and at the bottom by a stout cast-iron distance piece. The rear section of the bed plate, which supports the two cylinders, is cored hollow with a central dividing wall, giving two compartments which serve as reservoirs for incoming and outgoing circulating water.

The exhaust passages leading from the valve chambers are cored in the cylinder castings, in the under sides, and are water cooled. At the ends of each cylinder are horizontal side ports, resembling straight steam ports, which communicate with removable combustion chambers. The cylinders are closed by water-jacketed heads, those located between the two cylinders being split diametrically for facility in inspection of the interior, and the two halves are united with a ground fit, no packing being found necessary.

The location of valves and combustion

chambers in the new design is notable, and the valve gear is conspicuous for its simplicity. The combustion chambers are independent castings, with plain machined faces, circular, lined valve seats, and cored-out passages for circulating water. Both the admission and the exhaust valves, which are of the usual poppet type, operate vertically and with opposite throw. They are opened by a cam movement and are held on their seats by spring pressure. A central space, closed by the admission valve above and the exhaust valve below, communicates directly with the cylinder port before-mentioned; the exhaust valve chamber opens into the exhaust passages on the under sides of the cylinders, and the admission valve chamber into the supply pipe. This supply pipe is a rectangular cast-iron main extending along the entire front and provided with openings opposite each admission valve. It receives its supply from the governor chamber located midway between the two ends, this in turn communicating with a mixing chamber supplied with gas and air through suitable valves. These two valves are visible in Fig. 1; they are provided with graduated indices, so that the exact proportions of gas and air may at all times be ascertained by inspection, and are under the control of the attendant.

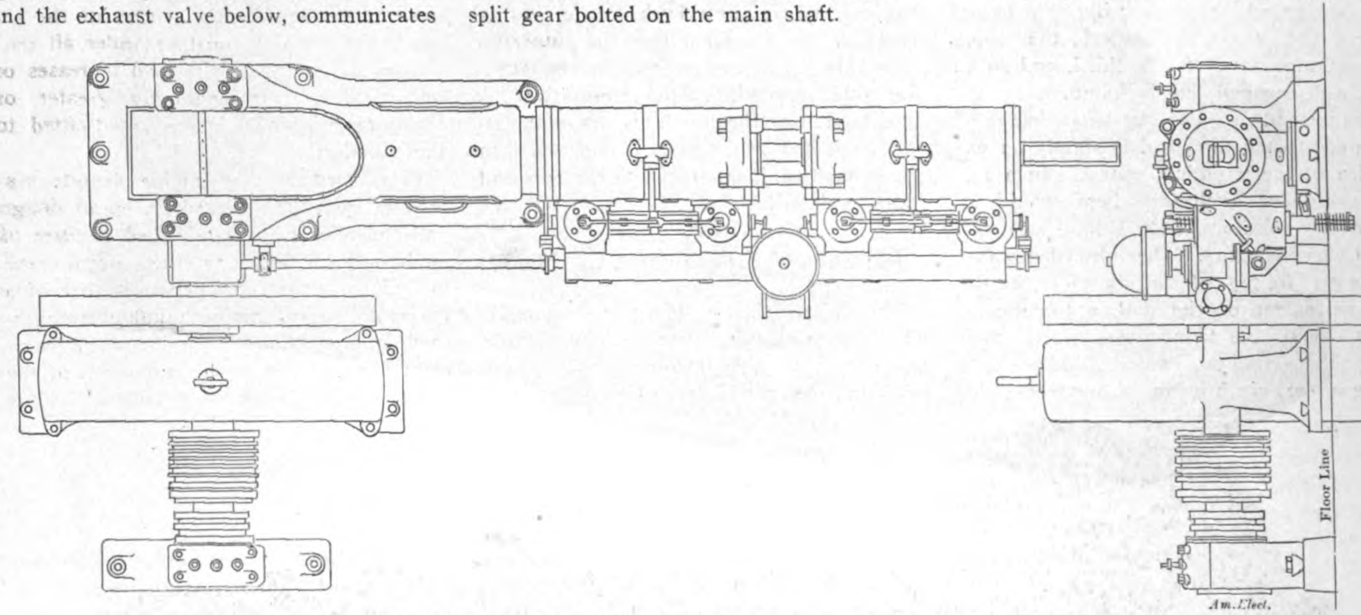


FIG. 3.—PLAN VIEW AND END VIEW OF SINGLE-CRANK WESTINGHOUSE GAS-ENGINE.

Each valve, together with its spindle and seating spring, is independently mounted, and by simply removing the bolts from the bonnet, the entire valve, seat and liner may be withdrawn. Similarly, the igniters, which are of the make-and-break electrical contact type, are mounted in a removable plug projecting into the combustion chamber through the side walls. The valve gear is of the cam and roller pattern employed in the Westinghouse vertical engines, and is driven by a helical gear, engaging a similar split gear bolted on the main shaft.

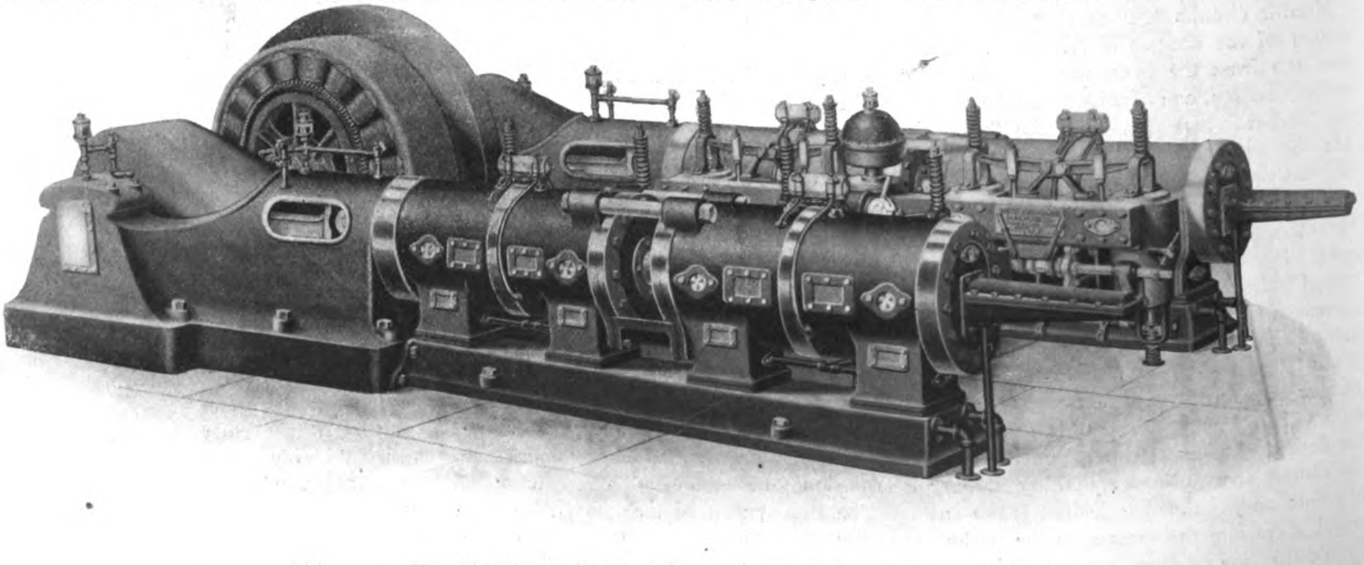


FIG. 2.—DOUBLE-CRANK WESTINGHOUSE GAS-ENGINE.

The cooling water is circulated through the pistons, of course. The water enters a cavity on the crosshead, from a flexible pipe connection provided with special swinging joints. It then flows through the hollow piston rod to the front and rear pistons, through which it circulates, finally emerging through a bronze tail rod extending through the rear cylinder head, and emptying into a cast-iron jacket communicating with the hot water return pipe. The value of piston cooling may be readily appreciated when it is considered that a cold piston clearance of approximately 1/16 in. is necessary in moderate-sized engines not fitted with water-cooled pistons. The pistons are built in two parts, with packing rings and babbitted bearing surfaces. They are secured in position on the rods by internal nuts and present plain convex surfaces to the burning gases. The piston rods are of forged steel, with bored-out water ducts. The packing for both piston rod and tail rod is of the metallic ring type.

The engine is started by compressed air pumped into a steel reservoir during a previous run before shutting down. For this purpose a special disengaging gear is provided which isolates the rear cylinder, and on admitting the compressed air, allows this cylinder to operate as an air motor until the regular combustion cycle is taken up in the forward cylinder. The rear cylinder may then be thrown into normal action. Oiling is accomplished by steam engine appliances, such as sight feed cups, cylinder pumps, and oil rings for crank pins.

The engine speed is controlled by a fly-ball governor of the standard design, protected by a circular housing. It operates a vertical piston valve to vary the quantity of fuel mixture according to the requirements of the load.

In the double-crank engine the cranks are placed 90° apart, giving four impulses per revolution, and a crank effort corresponding to that of a cross-compound double-acting steam engine.

DIRECT-CURRENT TURBINE-DYNAMOS.

The direct current turbine-dynamo made by the De Laval Steam Turbine Company, of New York, and shown in the accompanying illustration, would at first sight appear to be a radical departure from well-tried lines, but a close inspection will demonstrate that electrically, at least, the apparatus is identical with the ordinary electric generator. The novelty is entirely mechanical and consists in nothing more than combining the frames of two adjacent machines. The turbines and generators are direct connected by means of flexible coupling, and the combined units range in size from one kilowatt to 200 kilowatts. The units are self contained and the economy is said to be as good as that obtained with the best compound condensing engine, and the regulation is claimed to be within 2 per cent from no load to full load. Being turbine driven, there are, of course, few parts to get out of order, no valves to set, no stuffing boxes to be attended to, no bearings to adjust, no cylinder oil to be used, and, in fact, the unit approaches an ideal generating set in this respect.

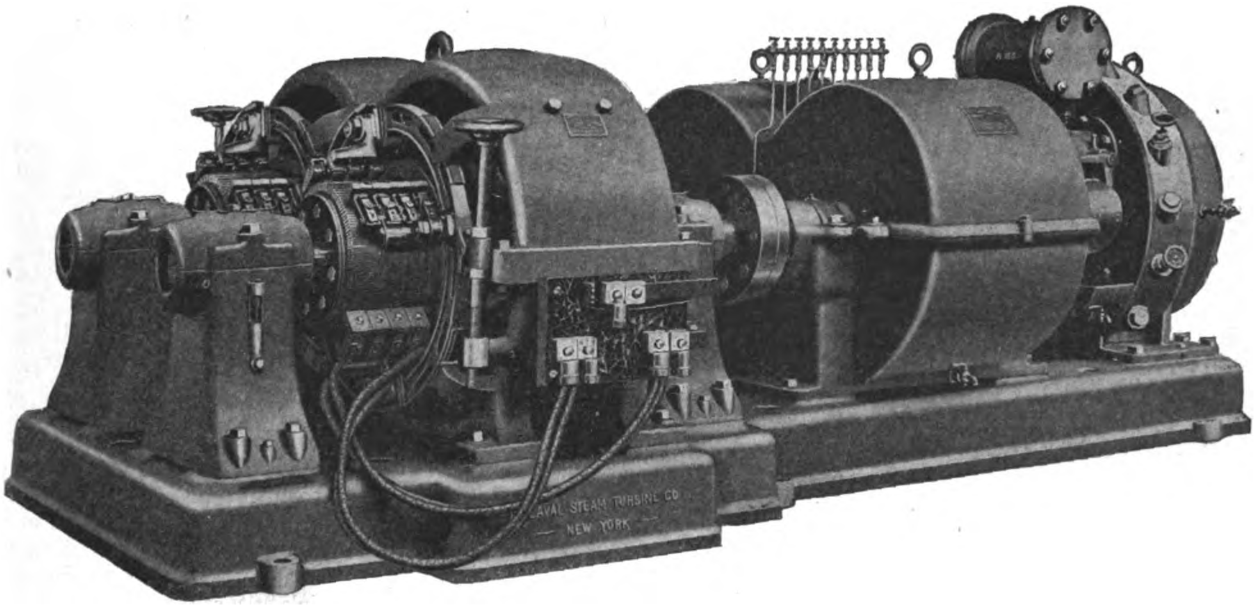


FIG. 1.—DE LAVAL 200-KW. DIRECT-CURRENT TURBINE GENERATOR.

The machines are mounted on a one-piece sub-base and have self-oiling bearings. The high-speed turbine bearings are oiled by means of a multiple tank oiler or with a gravity system using a large sized tank, the waste oil collecting in the base of the machine.

All units from 50 to 200 kilowatts inclusive, consist of two generators mounted side by side and geared together by means of turbine pinion and two gears; they can be used either on two or three-wire system, running two voltages from the same unit, or running motors at one voltage and lights at another. They may also be operated independently, the field circuits of one being broken and the machine entirely thrown off without in any way affecting the other.

The field frame is of cast steel, and in shape represents two intersecting circles, with the same centers as the two speed-reducing shafts. The frames are divided horizontally to admit of the removal of the upper half in placing or removing the armatures, the two halves being accurately located by means of dowels and securely held by heavy bolts. The upper half is provided with an eye-bolt to facilitate handling, and the lower half with feet which rest upon an extension of the turbine base. Vertical struts at the center of the frame add to its rigidity. The frame is designed to have inwardly projecting pole-pieces, and the circular form

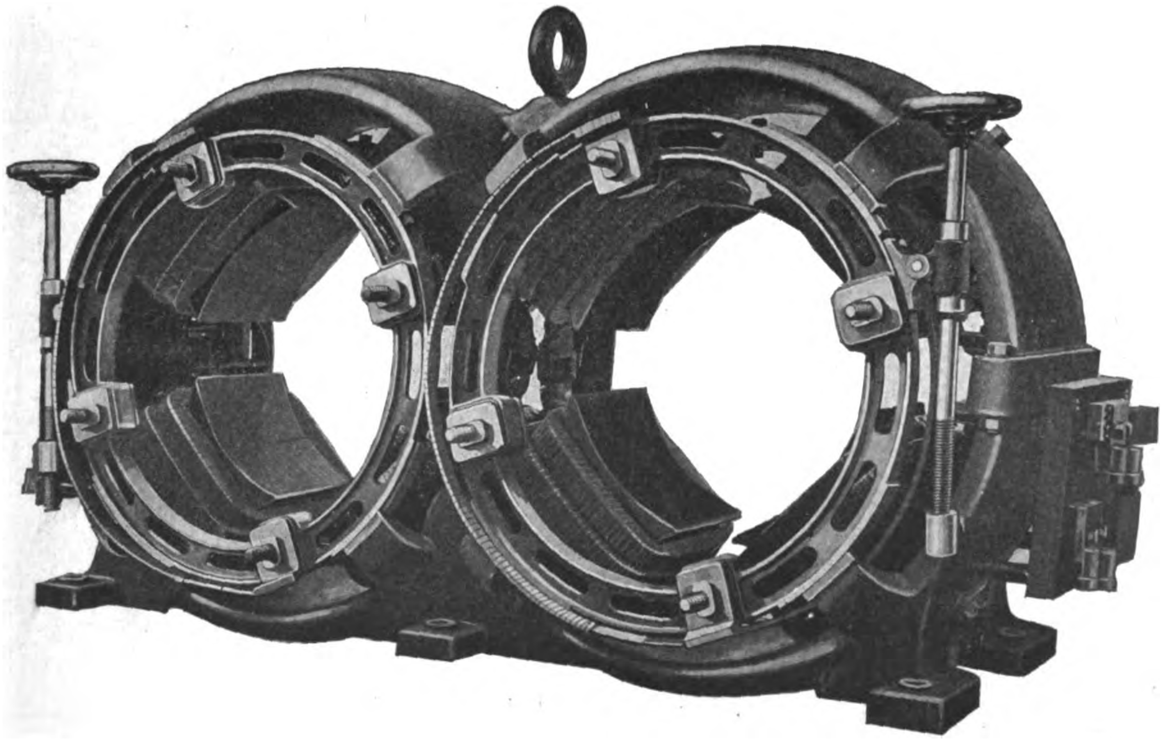


FIG. 2.—FIELD FRAME OF DE LAVAL 200-KW. DIRECT-CURRENT GENERATOR.

reduces, as much as possible, the length of the magnetic circuit. Brackets cast solidly with the frame carry the brush-holder yoke.

The field coils are machine-wound and are independently insulated and tested before mounting on the pole-pieces. The shunt and series coils of the compound-wound machines are separately wound and slipped over the poles before bolting to the frame, and may easily be removed if necessary.

The pole-pieces are built up of thin sheet-steel laminations, with pole-faces so shaped as to give the proper magnetic densities in the air-gap to ensure sparkless commutation, at the same time forming a support for the field coils. Each pole-piece is held in place by passing two bolts through the field frame, which not only secure the pole, but also draw it down to the tightest magnetic contact with the frame. The pole and field coils may be removed horizontally from the frame without disturbing the armature.

The armatures are of the ironclad, bar-wound, ventilated type. The cores are built up of thin annealed sheet-steel laminations, in the slots of which are carried the bar-wound armature coils, which are individually insulated and tested before placing. The bars are all of the same weight and length, making them interchangeable, and formed of one continuous bar of copper, doing away with soldered joints, except at connections with the commutator. Ventilating discs, containing air-ducts, are placed at frequent intervals throughout the armature cores.

The commutators are of heavy construction and so arranged as to be mounted directly on the armature shaft. These are built under heavy pressure, subjected to a baking process, and so constructed that they can be easily removed, if necessary. On the back end of each segment an ear projects above the brush surface of the commutator for receiving the soldered joint between the segments and the armature coils. The segments are insulated from the shell, wedge, and from each other by high-grade mica of a degree of softness which ensures its wearing evenly with the copper. The commutators are of such dimensions as to give large contact surface and working depth.

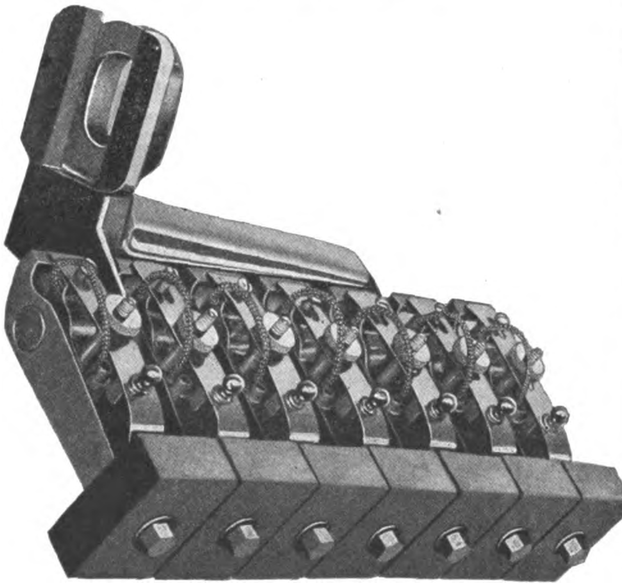


FIG. 3.—BRUSH HOLDER.

The brush-holders are of an improved design and are extremely simple in construction. These are of brass, of ample weight to carry the current without heating and to preserve rigidity of form. Carbon brushes are used, and each is secured to an independently adjustable holder. Adjustment of pressure is made through a screw on each holder, and each carbon may be raised from the commutator sufficiently high for inspection of the contact surface without disturbing the other brushes. Several holders are assembled on a brass stud, the number of holders so assembled depending upon the capacity of the machine, the number of such studs equaling the number of poles. Studs of like polarity are connected by copper rings which are joined electrically to the terminal boards on each side of the machine by means of flexible cables.

The brush-holder yoke consists of a circular cast ring supported by brackets projecting from the magnet frame in such a manner that a rotary motion may be given through the manipulation of the hand wheel. The brush holder studs are supported by current-carrying brackets attached to the brush-holder yoke through heavily insulated joints. The brackets are fixed, but may be adjusted vertically to compensate for wear of the commutator. The generators are built for either 125, 250 or 500 volts.

NEWSPAPER CONVEYORS.

A recent installation in the press room of the *Philadelphia Bulletin* shows a novel application of the link-belt conveyor which is utilized for handling the newspapers. The carrier is unique in several respects. There are three parallel roller chains of special design running on edge. The conveyor trough is of sheet iron and of sufficient depth to carry piles of 200 papers safely. It is scarcely two feet wide and follows a tortuous course around various obstructions. An auxiliary carrier, consisting of two parallel Ewart chains, conveys the papers from the fly boxes to a shelf alongside the trough of the conveyor. This enables the fly boy to stand upright and easily lift the papers in bundles of fifty to the chains of the carrier. The movement of this auxiliary carrier, it is claimed, is so timed that the ink dries sufficiently in transit to prevent smudging of the papers in handling.

There are seven large quadruple presses in the *Bulletin's* press room, each printing and pasting complete sixteen-page papers at the rate of 24,000 per hour, or twice as many eight-page papers in the same time. It is stated that before the introduction of the link-belt conveyor fourteen men with fourteen trucks were kept busy carrying these papers from the fly boxes to the circulation department. The Link-Belt Engineering Company, of Philadelphia, devised and installed this conveyor, which is driven by a 7½-h.p. Storey electric motor.

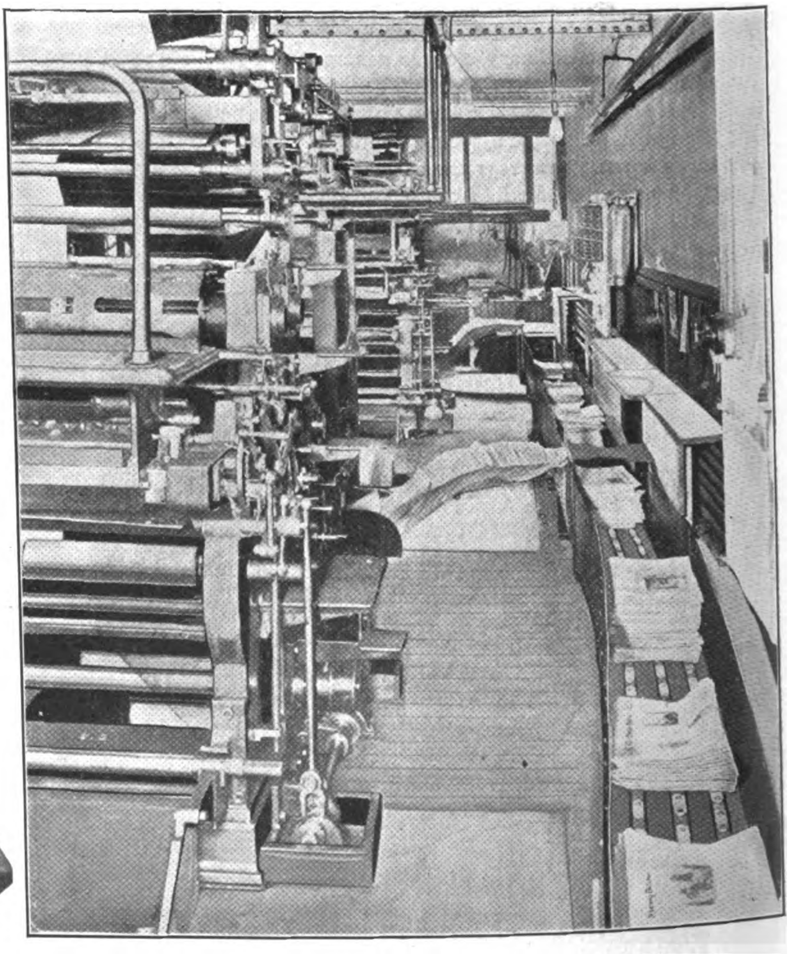


FIG. I.—PRESS ROOM SHOWING NEWSPAPER CONVEYOR.

New Apparatus and Appliances

THE G. D. EXTENSION CLOSER.

A new model telephone extension closer for ringing a battery call bell is illustrated by Figs. 1 and 2 herewith, Fig. 1 showing the simplicity of the device, and Fig. 2 showing it attached to the ordinary telephone magneto. The device is mounted on an electrose base, the metal parts being nickeled. A radical departure is made in employing the movement of the bell clapper, instead of the usual magnets, to release the drop shutter. There is a small switch provided, as shown at the bottom of Fig. 2, which may be used to open the extension circuit so that the extension bell will not ring when the shutter falls. The device is known as the G. D. extension closer, and is being manufactured by the Garton-Daniels Company, of Keokuk, Iowa.

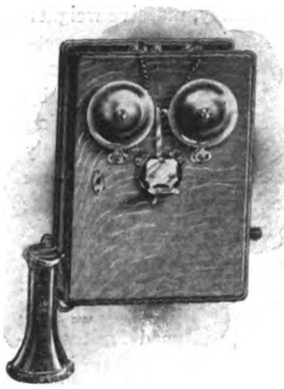


FIG. 1.

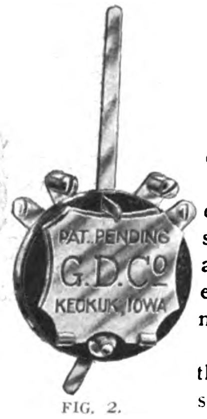


FIG. 2.

INTEGRATING WATTMETER FOR DIRECT CURRENT.

Fig. 3 herewith shows a new integrating wattmeter brought out by the Duncan Electric Manufacturing Company, of Lafayette, Ind., which, while especially adapted for measuring the energy of direct-current lighting and power circuits, will also, it is claimed, accurately measure alternating currents of any power-factor, wave form or frequency. Fig. 4 shows the meter with the case removed, Fig. 5 is another view with the front series coil removed to reveal the armature, and Fig. 6 is a side view showing the detachable and hinged case. The castings of the meter are made from nickel-aluminum, every part being easy of access and interchangeable.

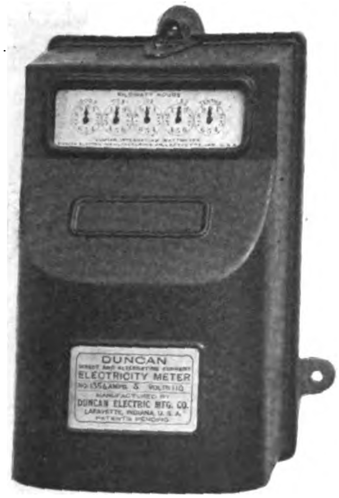


FIG. 3.—DUNCAN WATTMETER.

The terminals are situated at the top of the meter and connect the series coils with the inleading wires from the circuit, thereby removing these leads away from the retarding magnets at the bottom, and insuring in consequence a greater permanency and life for the magnets. The registering train is made large, and all of its parts are adjusted to insure ease of operation and freedom from "sticking." The pinions and gear wheels are cut accurately by automatic machinery, and assembled by experienced watch-makers. The train is provided with dowell pins, so that when it becomes necessary to remove it from its bracket it can be again put back into its position, thereby enabling the worm wheel and worm to mesh as originally set.

A commendable feature of the meter is that it is direct reading; that is, the dial shows at all times the actual amount of energy that has been consumed without having to employ a "constant." This eliminates a great source of trouble and inconvenience, and simplifies the work of the person who reads the meter.

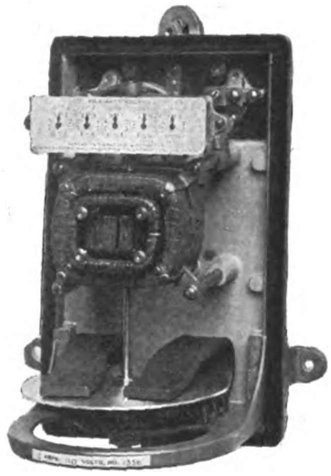


FIG. 4.—CASE REMOVED.

The cast back or support of the meter is provided around its outer edge with a groove that is lined with heavy felt, and over which the case closely fits, thereby rendering the meter dust and insect-proof. The dust-proof case is hinged at the bottom and is provided with a single screw at the top which answers for screwing it tightly into position and sealing the meter at the same time.

The series coils are machine-wound and heavily insulated with linen tape, after which they are immersed in copal varnish, then baked for several hours until they are thoroughly dry. The front series coil can very easily be removed from the meter by simply taking out the four screws that hold its corner clamps to the brass supporting rods. This removable feature of the front coil furnishes a quick and excellent means for inspecting the armature.

Realizing the trouble that has been experienced in the past with the commutator of this type of meter, the Duncan company has adopted a special alloy for this purpose. The segments are accurately cut and thoroughly insulated from each other and from the spindle, so as to prevent any possibility of the armature circuit becoming grounded at this point.

The brushes are detached by the removal of two small screws, which permits of their being lifted out for inspection without interfering in any way with the shunt-circuit wires.

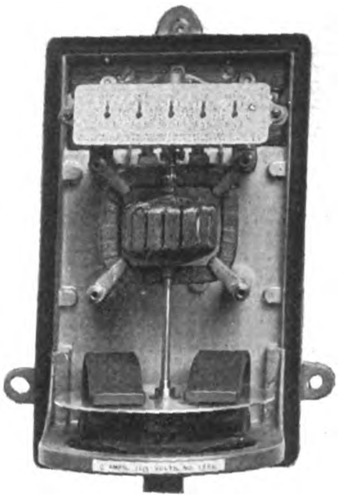


FIG. 5.—SERIES COIL REMOVED.

The company claims to have succeeded in procuring an especially high grade of Ceylon sapphire for jewels. These jewels are made in accordance with a special design, and polished until they are free from scratches or flaws of any kind. To protect the jewel against jarring and vibration it is seated upon a small spring, which is adjusted to balance the weight of the revolving element.

A diamond-jewel bearing may also be had with this meter. It consists of a diamond step, having a sapphire guide mounted upon it, and within which the spindle point revolves, the whole being seated upon a delicately adjusted spring, to protect it against jarring, in a manner similar to that of the sapphire bearing.

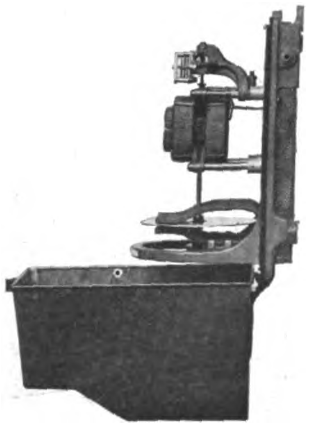


FIG. 6.—SHOWING DETACHABLE CASE.

Realizing the importance of having magnets that will withstand variations in temperature and mechanical vibration incident to shipping and handling and still maintain their strength for the purpose of enabling the meter to remain accurate for an indefinite period, the company has given a great deal of study, and made many experiments, with the view of producing magnets whose permanency or magnetic retentivity could be relied upon, and, from the results, it is satisfied that its efforts have been successful.

The usual means to compensate for the changes in friction of the meter is also provided to insure low-load accuracy. This consists of a small coil wound with many turns of fine wire and connected in series in the armature circuit and placed within the front series coil adjacent to the armature. It is held in position by four small wire brackets and thumb nuts, which prevent it from changing its position during shipment.

The testing constant (K) of each meter is marked upon the disc, and, as an example, it will be found in the case of a 10-ampere, 110-volt meter to be marked K ½. It should be borne in mind that this testing constant is to be used only in testing the meter, and must not be used in connection with the dial when the monthly readings are taken for the purpose of making out the bills for customers. The dials are direct reading and do not require any constants.

FRANCKE FOUR-PORTED ENGINE.

Fig. 7 herewith shows a new form of four-ported engine brought out recently by W. J. Francke, of New Brunswick, N. J., which is unique in several respects. A peculiarity of the engine is that it has but one valve, which is so designed as to give a four-valve steam distribution.

It will be observed that this valve is simply a cylinder with a steam port on one side and an exhaust port on the other; it is turned on the outside to fit a bushing containing the ports leading to the cylinders and on the inside to fit a tube containing the live steam ports. The valve is rotated by a pair of bevel gears from the shaft, running constantly in oil, and the speed at which it may be run is only limited by the speed which good engineering practice has demonstrated as possible for pistons and connecting rods properly counterbalanced and cushioned.

The valve is connected to the governor by means of a spindle which drives the governor, the valve rising and falling with the motion of the governor in a ratio determined by the relative length of the governor arms. The steam port in the valve, one edge of which determines the lead given to the engine, is cut longitudinally with the valve on its inside diameter so that the up-and-down motion imparted to the valve by the governor does not change the position of the valve with relation to the position of the piston, and the lead is maintained constant and may be changed at will without interfering with cut-off, release, or compression. On the outside diameter of the valve the form of the port changes so that two ports are formed which have a slant corresponding to the slant of the ports cut in the bushing in which the valve rotates; consequently, when the valve is raised by the action of the governor, the cut-off takes place earlier; and when the valve is lowered it takes place later, without in any way changing the lead, release or compression. The exhaust port in the valve is simply a slot cut longitudinally with the valve, one edge of which opens the port and the other port closes it; as the valve edge which opens the port does not close it, it follows that the position of the opening edge may be set in exactly that position which is determined by the indicator to be the best for the speed at which the engine is to run without interfering with lead, cut-off, or compression; and the closing edge may be set in exactly that position which is determined by the indicator to be the best to get the compression necessary for the economical use of steam and that smooth running and freedom from shock, which is so essential to high speeds. It will be observed, therefore, that this single valve in its exceedingly simple form gives a four-valve distribution of the steam, which allows the release and compression to be set independently of each other and allows any speeds to be attained without shock, jar or vibration, giving an automatic variable cut-off without excessive and wasteful compression. By referring to Fig. 8 it will be seen that the reciprocating parts of the conventional type of engine have been almost eliminated, leaving only the two connecting rods and pistons.

The governor is of the centrifugal type, but instead of having heavy, massive weights connected to an eccentric they are connected directly to the valve spindle itself, both the weight and the valve being driven by bevel gears from the main shaft, running continually in oil. The governor's only function is to raise or lower a balanced valve according to the load on the engine, a close regulation being obtained with light weights and springs. For lubrication ring oiling bearings are used for the shaft and an oil bath for the running gear in the crank case. A sight-feed lubricator is used for the pistons and valves. The exhaust steam is said to impinge on the flat surface of the exhaust valve port, forming an oil separator which spreads the oil over the entire surface.

MECHANICAL OIL CUP.

Fig. 9 herewith shows a new mechanical oil cup brought out by The Lunkenheimer Company, of Cincinnati, Ohio.

Referring to the illustration, it will be seen that the driving mechanism is of the ratchet type, and is operated by the clutches, *F* and *N*, that work co-operatively by the motion of the rod, *J*, which can be attached to the eccentric rod, or other moving parts of the engine, by the couplings, *K* and *M*. The motion thus obtained is transmitted to the piston, *E*, by the crank-pin mechanism, *H* and *G*. The ratchet wheel, *D*, is provided with a handle whereby it can be rotated by hand in case it is desirable to force a quantity of oil at any time, as, for example, when starting the engine. By moving the part, *K*, up or down the rod, the

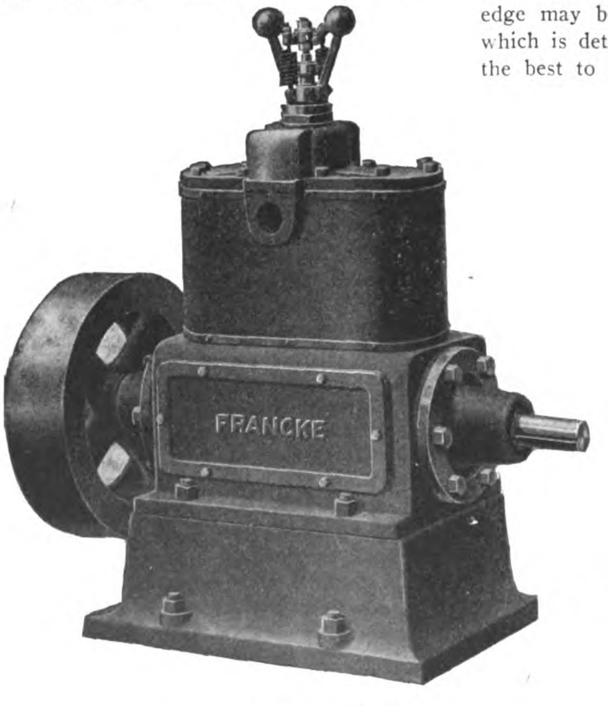


FIG. 7.—FRANCKE ENGINE.

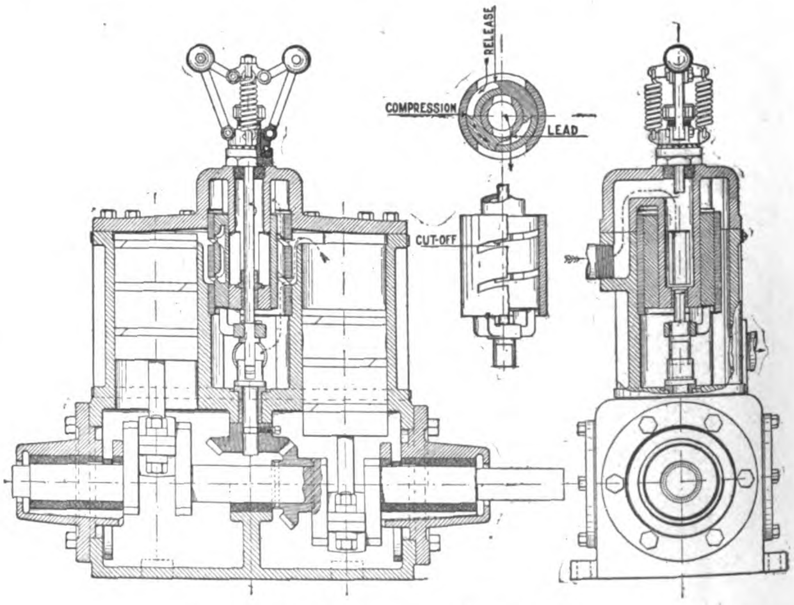


FIG. 8.—SECTIONAL VIEWS OF FRANCKE ENGINE.

stroke of the pump can be lengthened or shortened, as desired, thus regulating the amount of oil fed by the pump independent of the feed from the oil cup. The joints of the cup are tight, the sight-feed glass being packed so as to prevent the access of air that would have a tendency to cause the cup to feed after the engine had ceased running. This construction and the use of check valves in the pump prevent oil supply from flooding. The outlet, *C*, is piped to the steam pipe or chest of the engine, and the spring check valve, *X*, should be placed as near the end of the pipe as possible, preferably into the steam pipe. The bottom of the pump body, *B*, is tapped ½-in. pipe thread to receive a stand so that it can be placed wherever desired. The pump is substantially constructed, and, as the parts are made to jigs and templets, they can all be easily renewed, being interchangeable. The ratchet wheel, *D*, and pawls, *F* and *N*, are made of tool steel, tempered and hardened. All other metal parts about the pump are made of hard bronze composition.

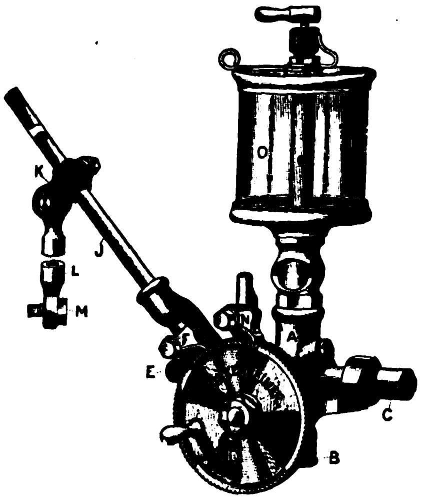


FIG. 9.—MECHANICAL OIL CUP.

GARRIGUS MECHANICAL BOILER CLEANER.

Fig. 10 herewith shows the Garrigus mechanical boiler cleaner, the manufacturer of which is the Mechanical Boiler Cleaner Company, of Chicago, Ill. The device it is claimed prevents the formation of scale, foaming, etc., and removes all foreign matter before it has an opportunity of settling. It operates as follows: The impurities in the water separate under ordinary working pressures and are held in suspension. The sediment thus formed, together with all earthy matter is carried by the currents to the surface of the water and then to the rear of the boiler, where it is arrested by the trough-shaped wings; when the junction of the wings is reached, the sediment is taken up by the floating skimmer, the mouth of which is always at the scum line, and discharged through the outlet pipe into the precipitator. The lower temperature of the precipitator and its special construction are said to cause the sediment to settle rapidly. It then remains in the lower compartment of the precipitator until it is drawn off by the blow-off pipe. The circulation is completed by the return pipe, which is connected with the boiler and takes only clear water from the precipitator. The sediment is thus said to be continuously and effectively removed from the boiler. The precipitator is blown off every two or three hours, an operation which requires about one minute. Fig. 11 shows a water-tube boiler with the cleaner attached, all of the details of construction being plainly indicated.

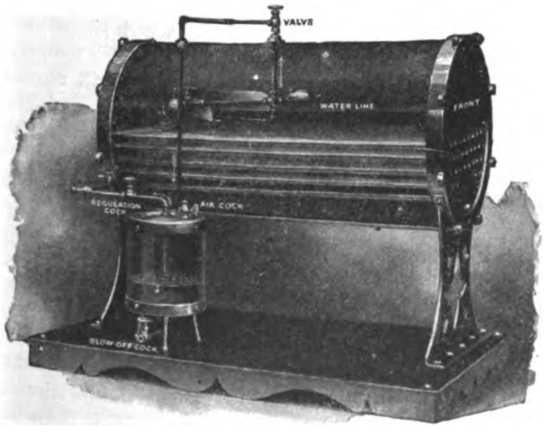


FIG. 10.—GARRIGUS BOILER CLEANER.

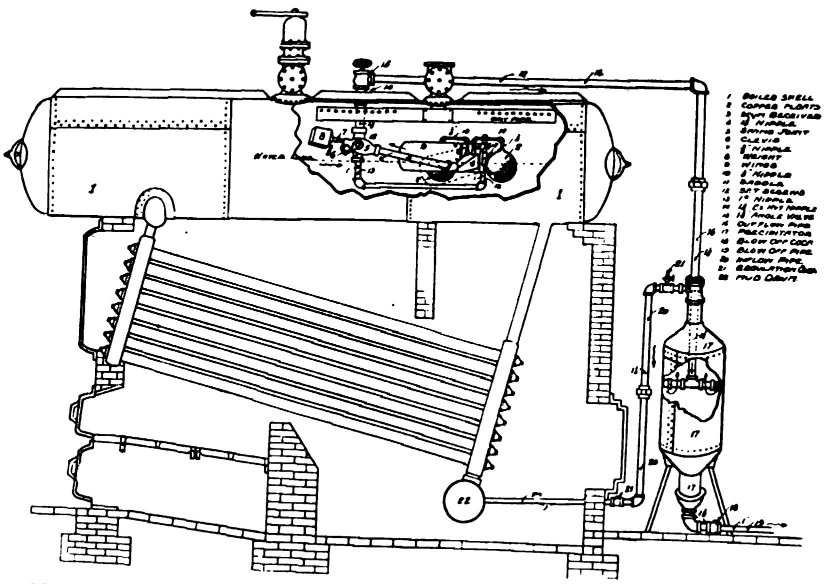


FIG. 11.—BOILER FITTED WITH GARRIGUS' MECHANICAL BOILER CLEANER.

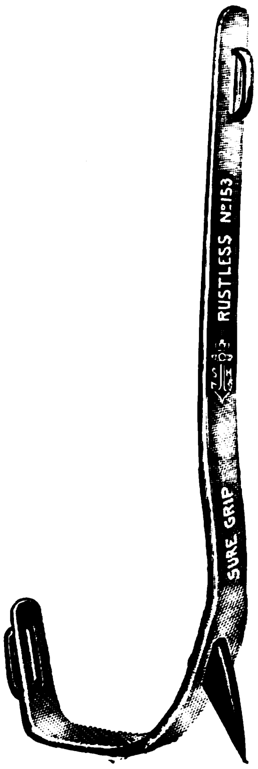


FIG. 12.—CLIMBER.

LINEMAN'S CLIMBER.

Fig. 12 herewith shows a new lineman's climber brought out by The Smith & Hemenway Company, of New York City. The climber is made of boracic steel, hardened and tempered, and is covered with a coating of white metal so as to render it as far as possible proof against excessive oxidation. The spur being welded in, makes the climber practically of one piece. The loops are made in the forging.

OIL CIRCUIT-BREAKER FOR HIGH-TENSION CIRCUITS.

The rapid increase during recent years in the size of central stations and the currents and voltages handled therein has necessitated a great development in the methods and apparatus for controlling and switching electric currents. While a few years ago most alternating-current switchboards were equipped with hand-operated knife switches, it is now found advisable and often necessary to use some means of auxiliary control. This permits the actual current switching devices to be located with regard to the general design of the station and a satisfactory lay-out of circuits and apparatus; at the same time it centralizes the control within a small space where the operator may have under his hand, so to speak, the whole station, and before his eyes an indication of the condition of every circuit.

One of the most remarkable pieces of apparatus which has contributed to make this great development possible is the high-tension, power operated, oil-break circuit-breaker. While the carbon shunt, open-air type of breaker, in which the arc is ruptured in the open air, has given excellent service in most classes of work, there are many places where, on account of space or other limitations, its use would not be feasible. It is to meet the need of a compact, safe and reliable device for rupturing high tension circuits that the oil-break circuit-breaker has been developed. The accompanying illustration shows a three-pole, double-break, automatic oil circuit-breaker, operated by electro-magnets. The circuit-breaker is erected in a masonry structure with each pole and oil tank in a separate, fire-proof compartment. There are two stationary contacts to the pole, one connected to the incoming lead and the other to the outgoing lead of the same phase, each contact being mounted in a large porcelain insulator. In the illustration one of the porcelain insulators is visible in the right-hand compartment.

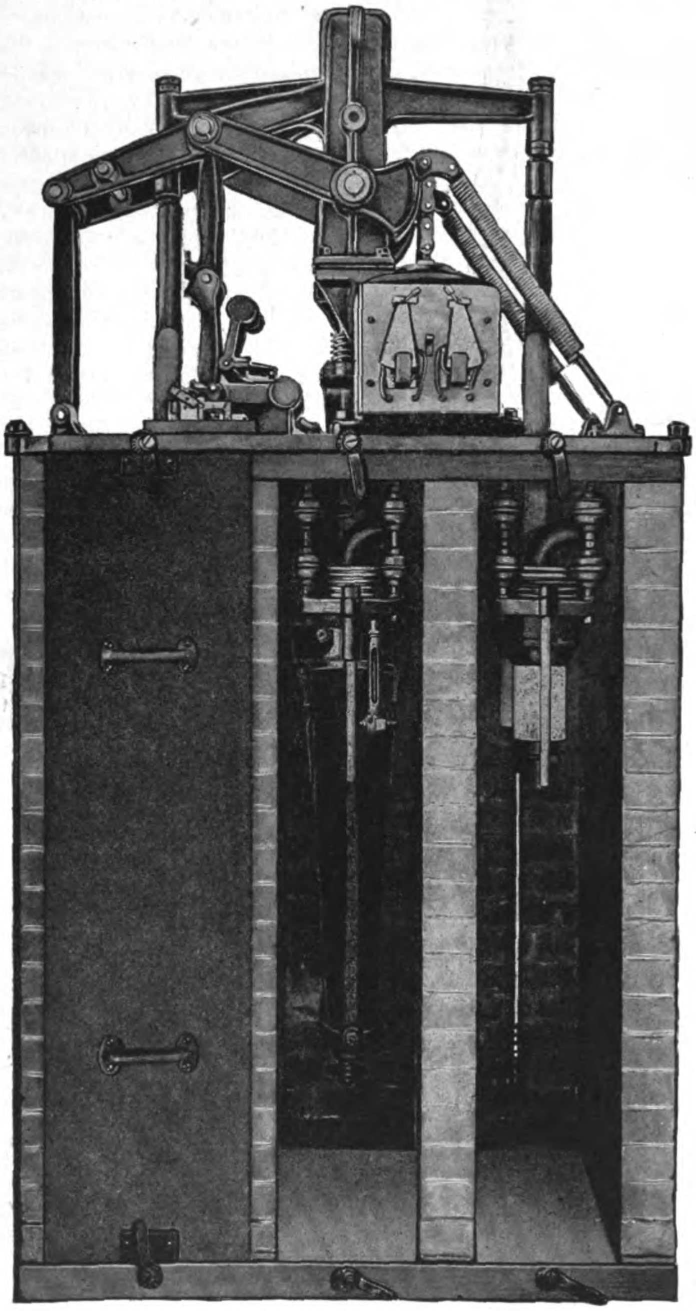


FIG. 13.—OIL CIRCUIT-BREAKER FOR HIGH-TENSION CIRCUITS.

The insulators are fastened to a cast iron frame which also supports the enclosing oil tank. The frame itself is supported from the soapstone slab at the top of the masonry walls by strain insulators. The movable contact for each pole consists of a U-shaped piece of copper fastened to the end of a stout wooden rod. In the closed position of the switch one of these U-shaped pieces electrically connects the two stationary contacts of each pole. The wooden rods are fastened at their upper ends to a common cross bar, which extends over the three masonry compartments and is supported by a system of levers giving a straight-line up-and-down motion. The cross bar is raised by the enclosing magnets, assisted at the beginning of the motion by a pair of balancing springs. The springs and the case containing the magnet are at the upper right-hand corner in the illustration. A toggle joint, shown at the left in the illustration, automatically locks this system of levers when the circuit-breaker is in the closed position.

The toggle joint is released by a blow from the tripping magnet, whereupon the cross bar, under the influence of gravity and a powerful spring, quickly drops, opening the contacts. The break takes place first at the main contacts and then afterward at a removable plug attached to the stationary contact which enters a hole on the movable contact. The plug thus receives all the effects of any arcing that there may be and, since it is removable, is easily replaced. The current for the closing and tripping magnets is derived from the exciters, storage battery, or other source of low-voltage, direct-current supply. If necessary, the circuit-breaker can easily be operated by hand without disturbing the mechanism in any way. The oil tanks, one of which is to be seen in the middle compartment, are constructed of heavy sheet metal and the interior is lined with insulating cement which is moulded to fit closely about the terminals and moving contact piece, leaving just room enough for the free movement of the parts in oil. By this means the amount of oil is reduced to a minimum. When the circuit-breaker is open, the wooden rod interposes an effective barrier between the two terminals of each pole. Suitable levers are provided for handling the tanks, which may be lowered away from the contacts and removed without disturbing the rest of the circuit-breaker. The entire circuit-breaker may be set in place and all parts adjusted before the oil tanks are placed in position. When necessary the tanks may be filled without removing them from their position. The oil level is easily seen by means of a small sight gauge. The tanks are insulated from the circuit and, all the live metal parts being immersed in oil, there is no possibility of receiving a shock from touching the breaker.

Mounted on each circuit breaker is a small double-pole, double-throw knife switch, which is used with the indicating and tripping circuits, and is operated by the motion of the levers of the circuit-breaker. The controlling and indicating devices consist of a controlling switch, an electro-mechanical, tell-tale indicator and a lamp. These are suitably mounted at the operating platform. A polyphase over-load relay, connected to series transformers in the main circuits, is provided for automatic opening. The controlling switch, which is of the drum type, has three positions, namely, "closed," "off" and "open." It will remain of itself in the "off" or the "open" positions only. In other words, if it is thrown to the "open" position it will remain in that position when the hand is removed, but if it is thrown to the "closed" position it will turn of itself to the "off" position, as soon as the handle is free. In the "off" position it connects the control circuit so that if the oil circuit-breaker opens through the action of any of the automatic devices the lamp will be lighted on the operating stand to attract the operator's attention. If the oil circuit-breaker is opened by the operator throwing the controlling switch to the "open" position the lamp does not light.

The mechanism of the electro-mechanical tell-tale indicator consists of an electromagnet which attracts a pivoted armature through an angle of about 90 degrees. Attached to the armature is a disc with a pointer which indicates to the eye the "open" or "closed" position of the oil circuit-breaker.

In the accompanying illustration the closing magnet is partly hidden by the overload relay. This operates on the principle of the single-phase induction motor. Each of the sectors swings between the poles of an alternating-current electro-magnet. Part of each pole is surrounded by a short circuited strip of copper, which acts to retard the magnetic flux and thus produce a shifting field. This tends to move the counter-weighted sectors which carry a contact closing the tripping circuit of the circuit-breaker. The two sectors are connected in parallel, and either alone will trip the breaker. The currents for their magnets are derived from the phases of the main circuit by series transformers.

The apparatus just described, known as the "Type C" circuit-breaker, is manufactured by the Westinghouse Electric & Manufacturing Company, whose engineers have devoted much attention to the development of simple and efficient means of operating switchboards in large power plants.

NEW TELEPHONE TRANSMITTER AND RECEIVER.

Figs. 14 and 15 show a new and interesting form of telephone transmitter brought out by the International Telephone Manufacturing Company, of Chicago. Fig. 14 shows an exterior view and the construction of the transmitter is plainly shown in Fig. 15. The case is a little less than three inches in diameter, and is properly proportioned and neat in design. The front is a heavy, nickel-plated brass casting on which are rigidly mounted all the working parts. The diaphragm is a flat metal disc and is provided with a rubber band around its edge to perfectly insulate it from the frame. The diaphragm is firmly clamped by two fork-shaped springs holding it evenly at four points, to leave the diaphragm free to vibrate. The carbon chamber is a very light metal cup mounted on the center of the diaphragm. The front electrode is spun into the bottom of the cup so as to leave no room for the granules to settle under its edge. The back electrode is mounted on a brass stud, which is provided with a washer and nut, to firmly clamp a mica ring. The outside of the mica ring is clamped by the rim of the light metal carbon chamber sealing the chamber perfectly.

The back electrode stud is set into a clamping device that is made in the form of a spring collet, allowing the electrode to be moved the slightest degree for adjusting. This adjustment clamping device is so arranged that it holds the electrode central with the diaphragm and obviates any indentation or side strain, which usually occurs from the side set screw. The adjusting device is set into a heavy, squarely-formed brass bridge from which it is properly insulated with hard rubber bushing and mica insulation. It is constructed very rigidly to avoid all possibility of throwing the instrument out of adjustment from heavy strains. The circuit from the front electrode is taken from the diaphragm to an insulated block mounted on one side of the bridge and the circuit from the back electrode is taken from the back electrode stud to an insulated block on the other side of the bridge. These conductors are of light metal punchings, formed to make rigid and durable connections without making it necessary to solder any joints of delicate wires. Both sides of the circuit are taken from the two terminals by insulated cord, 'through the arm to the terminal or induction coil, avoiding the use of any exposed parts of the transmitter frame or arm for any part of the circuit. Every detail part of this instrument is made by a special compound sub-die to make all like parts absolutely uniform, so that the instrument can be assembled without filing any part for fitting it. Any part becoming accidentally broken at any time can be readily replaced without returning the entire transmitter to the factory. The electrodes are of extra hard carbon, highly polished, and the granules are clean, hard granular carbon. The diaphragm is placed under the proper tension and the cup vibrates with the diaphragm, which keeps the granules agitated at all times.

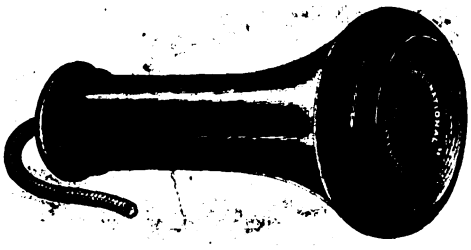


FIG. 16.—RECEIVER COMPLETE.

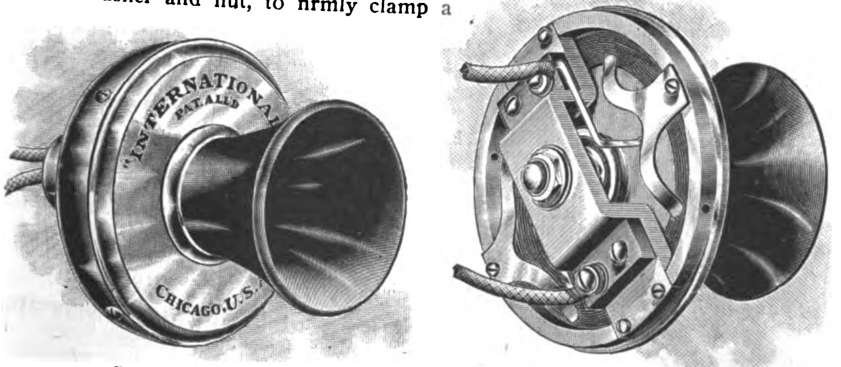


FIG. 14.—INTERNATIONAL TELEPHONE TRANSMITTER.—FIG. 15.

The telephone receiver is shown by Fig. 16, while Fig. 17 is a view showing the working parts. It has a horseshoe magnet constructed in one piece of magnet steel of sufficient length and weight to secure a strong magnet. The magnet is fitted at its pole ends into the adjusting block and firmly clamped to the bobbins and block by a heavy binding bolt and nut. The diaphragm is firmly clamped to a metal head by a threaded metal ring, leaving it free to vibrate, and independent of the rubber cap for its permanency. Its double-pole pieces are made of a special grade of soft Norway iron, thoroughly insulated and wound with silk-covered magnet wire. The cores are swaged under heavy pressure in a special die to make them absolutely uniform in width and provide positive stops for the spool heads. The ends are milled perfectly square in a special jig, making them all of one length. The spool heads are mounted and set to the cores by machine in a special tool, to give the bobbins all the same spacing. The spools being of one shape and size are interchangeable. The cores fit tightly into the adjusting block, making it impossible for the receiver to accidentally get out of adjustment.

The spools being practically the only working part of a receiver that are subject to destruction or naturally becoming defective, the receiver is made adjustable so this part may be conveniently and readily replaced and the receiver accurately and permanently adjusted. All working parts are self-contained and no part depends on the shell or cap for support. The magnet is fastened at its pole end only, so that the receiver is not affected by any difference between the contraction and expansion of the rubber shell and of the magnet steel. The magnet, together with the spools, are securely fastened into a strong cast brass threaded adjusting-block, which is fastened into a metal cup. The diaphragm is clamped firmly to the edge of this cup by a finely threaded metal rim. The adjustment is locked by two binding screws passing through slots in the cup, firmly clamping it to the adjusting block. Every detail part is made strong and durable. The shell which in itself is of extra thickness, has no strain or weight to hold, being only a cover to the working parts. The receiver can be used without its shell and the cap is provided with a small ridge around the hole, so that moisture due to long use of the instrument in hot weather will not enter and rust the diaphragm. The shell and cap are constructed of polished hard rubber. The coil wires are

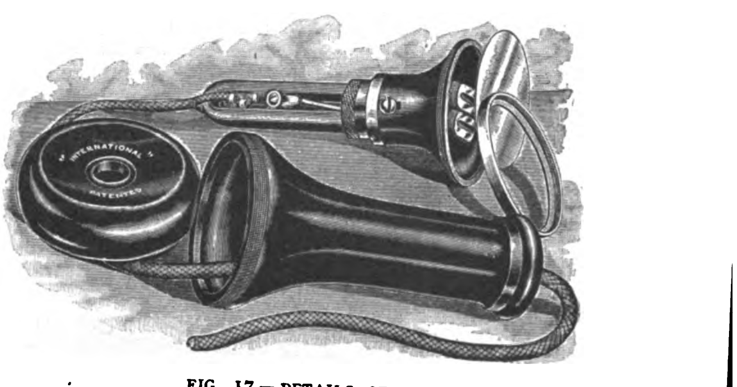


FIG. 17.—DETAILS OF RECEIVER.

of silk-covered magnet wire and lead through sleeving direct to the cord terminals, avoiding loose connections or open circuit in the receiver head. The cord terminals are mounted upon an insulating block, placed between the magnet bars. They are provided with a special cord clip to hold the cord by its braid and relieve the conductors of all strain. The outer ends of the cord are regularly furnished with a loop to fasten under a binding screw, and are provided with the ordinary cord tips if desired.

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NEW BOOKS.

The Art of Illumination. By Louis Bell, Ph. D. New York: McGraw Publishing Company. Cloth; 345 pages, 6 ins. x 9 ins.; 127 illustrations. Price, $2.50.

So far as the reviewer's knowledge extends, this is the only existing American book in which the subject of artificial illumination is covered with any degree of completeness. The first few chapters are slightly didactic, dealing with Light and the Eye, Principles of Color, Reflection and Diffusion, etc. The author then discusses illuminating materials and apparatus employed and methods of applying them, including those used in street lighting, domestic and decorative illumination. In short, the chief aim of the author is obviously to impart knowledge as to the correct use of illuminating mediums under the various conditions of practice. The construction and operation of lamps are considered only so far as is necessary to round out the discussion.

Elements of Electrical Engineering. By Tyson Sewell. New York: D. Van Nostrand Company. Cloth; 332 pages, 5½ ins. x 8 ins.; 204 illustrations. Price, $3.

As the title indicates, this is a book intended for beginners in the study of electrical engineering, and it is of the usual general character of such books. The author writes clearly, but occasionally fails to keep in mind the fact that certain things must, or at least may, be unknown to the reader or student. Thus in explaining Ohm's law, he refers to dynamos, voltmeters and ammeters repeatedly, notwithstanding this is the first chapter of the book and therefore no intelligible explanation of the functions of these pieces of apparatus has been given. The fundamental information is uniformly accurate, and most of the examples and illustrative analogies are well selected. The student who undertakes self-instruction by the aid of this book will find it of much assistance, provided he be not *too* raw a beginner; it requires well-developed powers of assimilation on the part of the reader.

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PERSONAL.

MR. E. W. RICHEY has resigned the superintendentship of the Union Elevated Loop in Chicago, in order to accept a responsible position on the staff of the Illinois Steel Company.

MR. MAX LOWENTHAL, who has for some time been on the engineering staff of the Prometheus Electric Company, has been appointed secretary of that organization.

MR. WILLIAM F. SINGER has been appointed New York manager for Fairbanks, Morse & Co., with headquarters at 133 Liberty Street. Mr. Singer was formerly in charge of the Indianapolis office of his firm.

MR. J. R. BIBBINS, of the Westinghouse Companies' Publishing Department, delivered an interesting address at the recent annual banquet of the New York Physics Club on the subject of Recent Developments and Uses of Electric Power.

MR. NORMAN P. BETHELL has been appointed manager of the electrical department of the Chicago Ship Building Company, to succeed Mr. Cyrus C. Mattison, whose resignation is noted elsewhere in this column.

COL. H. B. RAMEY, of the Peerless Electric Company, Warren, Ohio, has returned from a very successful trip abroad. Col. Ramey made his headquarters in London and succeeded in establishing valuable connections for his company.

MR. GEORGE H. MORGANSTERN, formerly manager of the sales department of the Baird Manufacturing Company, has accepted a similar position with the Vought-Berger Company, La Crosse, Wis., well-known manufacturers of telephones and telephone appliances.

MR. BEVERLY R. VALUE, third division engineer of the Rapid Transit Commission, of New York City, has resigned to accept a position with the Toronto Light & Power Company. He had charge of the underground work north of 104th Street, on the Manhattan-Bronx subway.

MR. THOMAS CASEY, for several years superintendent of J. H. Bunnell & Company and later superintendent of the Bunnell Telegraphic & Electrical Company, has been appointed superintendent of the Jersey City factory of the Manhattan Electrical Supply Company.

MR. DANIEL SKELTON has been appointed superintendent of the American District Telegraph Company, New York. Mr. Skelton has occupied positions of every grade in the service of his company, having entered it as a messenger twenty-seven years ago.

MR. CYRUS C. MATTISON, who has been in charge of the electrical department of the Chicago Ship Building Company for the past seven years, has severed his connection with that company and accepted a position with the Grand Crossing Tack Company.

MR. CHARLES WIRT has been awarded the John Scott medal of the Franklin Institute for his improvements in electrical rheostats, more particularly, the feature of a continuous (integral) ribbon conductor, the cross-section of which decreases gradually from one end to the other of the conductor.

MR. F. S. PEARSON has just returned from a successful trip to Mexico. Mr. Pearson is one of the originators of the Mexican Light & Power Company which has been organized with a capital of $12,000,000 for the purpose of constructing a power transmission plant to supply Mexico City and the vicinity with electricity for lighting and power.

MR. FRANK B. RAE, the well-known consulting electrical engineer, has arrived at Parral, Mexico, and is looking over the ground at the mines of the Terrenates Consolidated Mining Company preparatory to the installation of a complete electrical equipment. The plant will consist of two 300-h.p. De Laval turbine dynamos of 200 kilowatts each, two 50-h.p. electrical hoists and two 350-gal. pumps. Power will be transmitted on aluminum conductors 1¼ miles to the distributing center. These are the first De Laval turbines to be installed in a Mexican mine—probably the first in Mexico—and it is believed that the plant will be one of the most economical in the district.

MR. W. D. SARGENT, the popular vice-president of the New York & New Jersey Telephone Company, was married recently at Somerset, Pa., to Miss Mary Kooser, daughter of Judge Kooser. The party from Brooklyn had difficulty in getting there, owing to the heavy snowstorm. Their train over the Pennsylvania Railroad was four hours late and it missed connections with the morning train over the Baltimore & Ohio. The afternoon train would not arrive at Somerset until two hours after the time set for the wedding, and the couple had arranged to start on the afternoon train for their bridal trip. A yard engine was pressed into service, however, and hauled the car in which the party was traveling out to Somerset a short time before the hour set for the wedding.

COL. HENRY G. PROUT, for many years editor of the *Railroad Gazette*, has been appointed vice-president of the Union Switch & Signal Company, Swissvale, Pa. Col. Prout is an engineer of widely varied experience. He graduated from the University of Michigan with the degree of Civil Engineer, practiced this profession in railroad surveying through the Rocky Mountains for some time, and then entered the service of the Khedive of Egypt as major of engineers. Returning to America, he became signal engineer for the Union Switch & Signal Company and in 1887 assumed the editorship of the *Railroad Gazette*, which position he held continuously and with conspicuous success until his present appointment.

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MR. ARTHUR WILLIAMS, of the New York Edison Company, who was appointed by President Ferguson, of the National Electric Light Association, to report on decorative lighting at the coming convention of the Association, has written to all active members asking them to send him illustrations of all the designs of display lighting installed by them. Mr. Williams will have half-tone engravings made of these and submit them in connection with his report.

MESSRS. JOHN W. GROVE and L. L. KNOX have formed a partnership under the style of Grove & Knox for the purpose of doing all kinds of furnace engineering and contracting and serving as selling agents for manufacturers of iron and steel castings, crane chains, Goheen paint, Hassel limit switches, and other good specialties. Mr. Grove was formerly treasurer and general manager of James W. Grove & Co., Pittsburg, and Mr. Knox was the Pittsburg manager for M. H. Treadwell & Co. The new firm will have temporary offices at 1105 Peoples Bank Building until April 1, when they will move into a suite of offices in the Farmers' National Bank Building.

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TRADE PUBLICATIONS.

ASBESTOS BOILER COVERINGS. H. W. Johns-Manville Company, New York.—A pamphlet of convenient size, containing illustrations and descriptive matter relating to asbestos coverings for boilers, heaters and similar surfaces.

ELECTRIC COOKING AND HEATING APPARATUS. The Prometheus Electric Company, New York.—A handsome catalogue of standard size, containing well executed illustrations of electric cooking utensils, stoves, sad iron heaters, radiators, glue pots, etc.

AUTOMOBILE CHARGING OUTFITS. Westinghouse Electric & Manufacturing Company.—This is Circular No. 1061, containing an illustrated description of an extensive line of automobile charging outfits and switchboards. Ten styles of charging panels are shown in the bulletin.

EBONITE COMMUTATOR COMPOUND. E. M. Ashmore & Co., Detroit, Mich.—This is a booklet of testimonial letters from users of "Ebonite" commutator compound, and the character of the various testimonials amply justifies their publication.

TO BATTERY USERS. William Roche, New York.—A pocket-size pamphlet containing an illustrated description of the Roche double-pole igniter plug for gas and gasoline engines, spark coils for the same class of service, the Roche auto-gas dry battery for gas engine service, gas lighters, incandescent flashlights, etc.

MICALITE. Eugene Munsell & Company, New York.—A pocket-size pamphlet of mica specialties which have been given the trade name of "Micalite," being made for use in connection with illuminating mediums, such as incandescent lamps, gas burners, etc. The list includes reflectors, canopies and lamp chimneys.

MALLEABLE IRON LINE CONSTRUCTION SUPPLIES. Electrical Construction Supply Company, Springfield, Ohio.—A pocket-size pamphlet in which are illustrated and described a very complete line of malleable iron insulator pins, combined brackets and insulator pins, break arms, and arc lamp suspension pulleys.

LET'S TALK IT OVER. The Lagonda Manufacturing Company, Springfield, Ohio.—A folder purporting to record a talk by an engineer on the subject of the Weinland boiler tube cleaner. The talker of course points out the meritorious features of the tube cleaner, so that when one has read the folder through he has a very good practical idea of its points.

WOOD FAN MOTORS. Fort Wayne Electric Works, Fort Wayne, Ind.—A beautifully executed catalogue containing a detailed description, with illustrations, of the direct-current and alternating-current fan motors built by this company. The catalogue also contains handsome illustrations showing various applications of the Wood fan motor.

DIRECT-CURRENT TURBINE DYNAMOS. D'Olier Engineering Company, Philadelphia, Pa.—This is Bulletin T-2, containing an illustrated description of the De Laval twin turbines and dynamos, a description of which appears elsewhere in this number. The D'Olier Engineering Company is district selling agent for the De Laval Company.

ENCLOSED ARC LAMP INNER GLOBES. The Shelby Electric Company, Shelby, Ohio.—A catalogue of convenient size for the coat pocket, containing outline illustrations of the various globes, on which are marked their actual dimensions. The line manufactured by the Shelby Company includes every standard shape of inner globe used on American enclosed arc lamps.

ELECTRICAL SPECIALTIES. Pass & Seymour, Solvay, N. Y.—Catalogue No. 14, devoted to the high-grade porcelain specialties manufactured by this company. The catalogue is well executed and contains full-size illustrations of Pass & Seymour cleats, rosettes, tubes, receptacles, lamp sockets, switches and other specialties, together with price-lists and a telegraph code.

EMERSON FAN MOTORS. The Emerson Electric Manufacturing Company, St. Louis, Mo.—The 1903 catalogue of fan motors and ventilating outfits built by the Emerson Company. The catalogue is handsomely executed and contains detailed descriptive matter, with price-lists and a telegraph code, as well as the usual catalogue material.

A COMPREHENSIVE ENGINE TEST. Buffalo Forge Company, Buffalo, N. Y.—This is a very handsomely executed booklet of pocket size, containing a full report of a test, made at Massachusetts Polytechnic Institute by Prof. Sidney A. Reeve, of a Buffalo Forge single-cylinder center-crank horizontal non-condensing engine. The results of the tests are interesting; among these may be noted the fact that at normal cut-off and with 125 pounds steam pressure the engine developed 126 horse-power at 322 r.p.m. with a water consumption rate of 27.6 pounds per horse-power.

PLUNGER ELEVATORS. Plunger Elevator Company, Worcester, Mass.—A pamphlet catalogue of pocket size, containing a description and illustrations of the plunger type of hydraulic elevator built by this company. The catalogue also contains well executed pictures of some of the large buildings in which these elevators have been installed, notably the Ansonia apartment house, New York; the Empire Building, Atlanta, Ga.; and the Board of Trade Building in Boston. It is noteworthy that the elevators in the Ansonia apartment house have a travel of 223 feet.

ELECTRO MAGNETS. Varley Duplex Magnet Company, Phillipsdale, R. I.—This is catalogue No. 10, which has been prepared in the usual comprehensive and comprehensible manner that characterizes Varley catalogues. It contains perspective illustrations of the ringer magnets, induction coils, solenoids, and other coils made by the Varley Company, together with net prices and advisory data. The section of the catalogue devoted to solenoids is particularly valuable to any one interested in that class of apparatus, as it gives actual dimensions of a line of iron-clad solenoids, together with curves showing the performance of the largest one of the list. Similar data relating to the other sizes will be supplied on application.

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BUSINESS NEWS.

BUFFALO FORGE COMPANY, Buffalo, N. Y., has removed its Cleveland office from 910 New England Building to 1114 Citizens' Building.

STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago, recently closed a contract with the Citizens' Telephone Company, Grand Rapids, Mich., for a 160-line switchboard equipment.

MARSHALL-SANDERS COMPANY, Boston, Mass., reports most gratifying results with the new elastic socket lining described in the January number of this paper. This lining meets all the requirements of the National Board of Fire Underwriters.

ELECTRICAL MATERIAL COMPANY, Baltimore, Md., reports such a demand for Nernst lamps in its territory that it has filled orders from stock with difficulty, notwithstanding the fact that a large stock is carried in the Baltimore house.

JAMES McCREA & CO., Chicago, report a brisk trade in Climax steam joint clamps. Among recent sales were twenty-four 4-in.; the same number of 5-in., 6-in. and 8-in. clamps; twelve 10-in.; six 12-in., and six 14-in. clamps to the Delaware, Lackawanna & Western R. R. Company.

THE DAYTON GLOBE IRON WORKS COMPANY, Dayton, Ohio, has arranged with the Pelton Water Wheel Company, San Francisco, to act as its representative on the Pacific Coast. The Pelton Company will therefore have the exclusive right to sell the new American turbines in this territory.

A BOOK ABOUT NEBRASKA.

A new publication just off the press. The best and most comprehensive work on Nebraska ever issued. It gives a host of valuable information, is filled with illustrations, has a large sectional map of the State, and fully explains why Nebraska is the place where men who want to get ahead should go. There is no country in America where the opportunities are greater. Send to me for a copy. No charge. P. S. Eustis, Passenger Traffic Manager C. B. & Q. Ry. Co., 209 Adams Street, Chicago.

SOLID TRAINS TO NORTHERN MICHIGAN.

The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.

All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

A Telephone Subscriber

has every advantage afforded by a comprehensive telephone system; incidentally, his name appears in the best of all directories.

Low Rates. Efficient Service.

NEW YORK TELEPHONE CO.
15 Dey Street, 220 West 124th Street,
111 West 38th Street, 614 East 150th Street.

An INCANDESCENT LAMP represents a large investment of capital, ingenuity and skilled workmanship, it is sold at a price so low as to necessitate eternal vigilance in cutting costs to a minimum. A successful lamp manufacturer can not afford to experiment with poor materials. This explains the popularity of

BAKER & CO.'S PLATINUM

408 N. J. R. R. Ave., NEWARK, N. J. 120 LIBERTY ST., NEW YORK

We buy and Refine Platinum Scrap also

BROWN-CORLISS ENGINE COMPANY, Corliss, Wis., reports continued briskness in the line of heavy-duty Corliss engines for electric light and power plants. Engines were recently shipped to the Sheffield Company, Sheffield, Tenn.; the Louisville Gas Company, Louisville, Ky., as well as several electric lighting stations.

NEW YORK & OHIO COMPANY, Warren, Ohio, announces that it has added to its well-known list of electrical manufactures a line of insulating cloths and varnishes, the development of which, the company states, was due to its own extremely rigid requirements for this class of material to be used in Packard transformers.

BURT MANUFACTURING COMPANY, Akron, Ohio, continues to ship large numbers of Cross oil filters to all parts of the United States and to many foreign countries. Recent export shipments of filters were made to Australia, Sweden and South Africa. Among notable domestic sales is noted a fifth order from the American Locomotive Company, Schenectady, N. Y.

THE THOMAS E. CLARK WIRELESS TELEGRAPH & TELEPHONE COMPANY, Detroit, Mich., recently shipped a complete set of wireless telegraph apparatus to Ft. Wayne, Ind., to be taken to the Philippine Islands with the 14th Regiment of U. S. Infantry. The company has also shipped a set of instruments to the War Department for use at San Francisco.

THE ELECTRIC APPLIANCE COMPANY, Chicago, announces that it carries the largest stock of Circular Loom conduit in the West. The sizes carried in stock range from ¼ inch to 2¼ inches inside diameter, and the quantity of each size that is kept on hand is sufficient to enable the company to fill any reasonable order immediately upon its receipt.

THE ROCHESTER MACHINE TOOL WORKS, LTD., Rochester, N. Y., reports that the results achieved in recent installations of its engines in electric lighting and power plants are exceedingly satisfactory. This company is manufacturing engines for direct-connected work which are claimed to run smoothly at speeds ranging from 100 to 800 revolutions per minute, and to govern within 2 per cent from no load to full load.

NORTHERN ELECTRICAL MANUFACTURING COMPANY, Madison, Wis., has completed the new power plant at its factory and the plant is now in operation. It consists of a 200-kw. Northern generator direct-driven by a 225-h.p. Vilter Corliss engine, and a 50-kw. Northern generator driven by a 75-h.p. Ball engine, the large unit being used for the day load and the small one for night work. The shops are lighted by incandescent lamps supplied through a motor-generator set which is operated from the power bus-bars.

GOULD STORAGE BATTERY COMPANY, New York, reports among recent contracts the following: A 196-cell battery, with switchboard equipment, to the Philadelphia & Lehigh Valley Traction Company; a 240-cell battery, with switchboard and booster, to the Warren (Pa.) Electric Street Railway Company; four batteries of 305 cells each to the Dayton & Muncie Traction Company; a battery of 124 cells to the Odell (Ill.) Illuminating Company, and a battery of 56 cells, with switchboard and booster, to the Manhattan Light, Heat & Power Company, St. Paul, Minn.

THE CHARLES EFROS COMPANY, Bayonne, N. J., has embarked in the second-hand machinery business on a very large scale. The company has an extensive site on which are several large factory buildings and which are provided with ample railroad facilities. The mechanical details of the business will be under the supervision of Mr. R. B. Corbett, formerly with the A. G. Schoonmaker Company. The company is just now handling only boilers, engines, piping and mechanical appliances and parts, but other lines will be added as rapidly as practicable.

A CORRECTION. In this department last month it was announced that the Christensen Engineering Company had established a Philadelphia office in charge of Mr. H. A. Pike. This statement was erroneous, the office that was established in Philadelphia being accredited to the Christensen Engineering Company by mistake instead of to N. A. Christensen, who now controls the air compressor business formerly handled by the Christensen Engineering Company. Mr. Pike has been appointed Philadelphia manager for Mr. Christensen, but not for the company which bears his name.

THE FOSTORIA INCANDESCENT LAMP COMPANY, Fostoria, Ohio, has been awarded the contract for furnishing all standard lighting and car lighting incandescent lamps for the New York Central Railroad and all of its leased and operated lines for one year. It is estimated that this contract will cover 75,000 lamps. The Fostoria Company feels particularly gratified over securing this contract because the New York Central has been buying Fostoria lamps for the past four months on a contract for 10,000 car lighting lamps, so that the new contract is evidently based on actual experience with these lamps.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, has adopted a policy concerning the renewals of plates in "Exide" batteries which should attract the favorable attention of users of electric vehicles. Detailed information regarding this may be secured from any of the sales offices of the company or from the "Exide" battery depots at Philadelphia, New York, Chicago, St. Louis, Buffalo, Rochester and Detroit. A noteworthy feature of the recent Automobile Show at Madison Square Garden, New York, was the fact that of the eight manufacturers of electric vehicles who exhibited six used the "Exide" battery.

ALLIS-CHALMERS COMPANY, Chicago, will remove its general offices on May 1 from the Home Insurance Building to the New York Life Building at the corner of La Salle and Monroe Streets. The new offices will provide much larger space for the various sales departments and divisions of the business department, which the enormous growth of the company has rendered imperative. It is interesting to note that during the past two months orders for machinery of some kind have been received from every State in the Union, as well as from England, South Africa, Canada, Mexico, Central America, Chili, Brazil, Bolivia, Peru, Australia, Turkey, Finland, Belgium, China, the Philippine Islands, and the Hawaiian Islands.

EWING-MERKLE ELECTRIC COMPANY, St. Louis, Mo., has been organized for the purpose of engaging in a general electrical supply business. The organizers of the new company are N. W. Ewing, formerly assistant treasurer of the Western Electrical Supply Company; W. S. Merkle, formerly manager of the engineering department of that company; W. G. Brown, formerly manager of the apparatus department of the same company, and Milton Mill, formerly assistant manager of the Western Electrical Supply Company. The new concern has secured quarters in a six-story building at 1106 Pine Street and has extremely bright prospects for a successful future.

THE NEW WESTINGHOUSE GAS ENGINE, described at length in another part of this issue, has already received a substantial commercial recognition. The first engine of this type will be put into operation at the works of the Consolidated Industries Company, Batavia, N. Y., and will be a single-crank 250-h.p. machine direct-connected to a Westinghouse alternator. Another installation of engines is to be made shortly at the works of the Atlanta Refining Company, Philadelphia; these engines will be of the twin type, having a capacity of 500 horse-power per unit. A third plant, aggregating 1200 horse-power in single-crank gas engines, is to be installed at Hillburn, N. Y., these engines being direct-connected to Westinghouse polyphase alternators intended for parallel operation.

AUTOMATIC ELECTRIC COMPANY, Chicago, reports that it is to supply the telephone apparatus that will be installed by the Commonwealth Telephone Company organized in January at Waterloo, Iowa. This company has secured control of some half-dozen local exchange systems in Iowa, which are to be equipped with the Automatic Electric Company's apparatus, as just stated. The Automatic Company recently shipped to the Mutual Automatic Telephone Company, Albuquerque, New Mexico, a switchboard of 1000 lines ultimate capacity, with 400 telephones and switches, for present installation. The city of Albuquerque has had automatic telephone service for seven years, the local company having purchased one of the early types of Strowger switchboards. The new equipment was purchased to meet the demand for service beyond the capacity of the switchboard which has been in use.

WESTINGHOUSE, CHURCH, KERR & CO. announce that the steam turbine equipment of the Hartford Electric Light Company is to be extended in the near future by the addition of two 1000-h.p. Westinghouse turbines direct-connected to polyphase alternators. This energetic firm also closed a contract recently with the New York Edison Company for another 6500-h.p. Westinghouse vertical three-cylinder compound engine of the same type as the eight engines already in operation or being installed at the Waterside station. This makes the eleventh engine of this type and size that has been sold to the Edison Company, the first order being for the historical eight units and the second for two more units. Westinghouse, Church, Kerr & Co. have also taken an order from the New York Central & Hudson River R. R. Company for four Westinghouse Corliss engines of the horizontal cross compound type, which will constitute the main equipment of the New York Central's power station in process of erection at Weehawken.

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THE WARREN COMPANY MFRS.,
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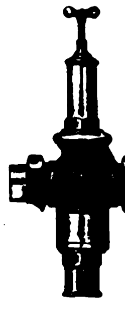

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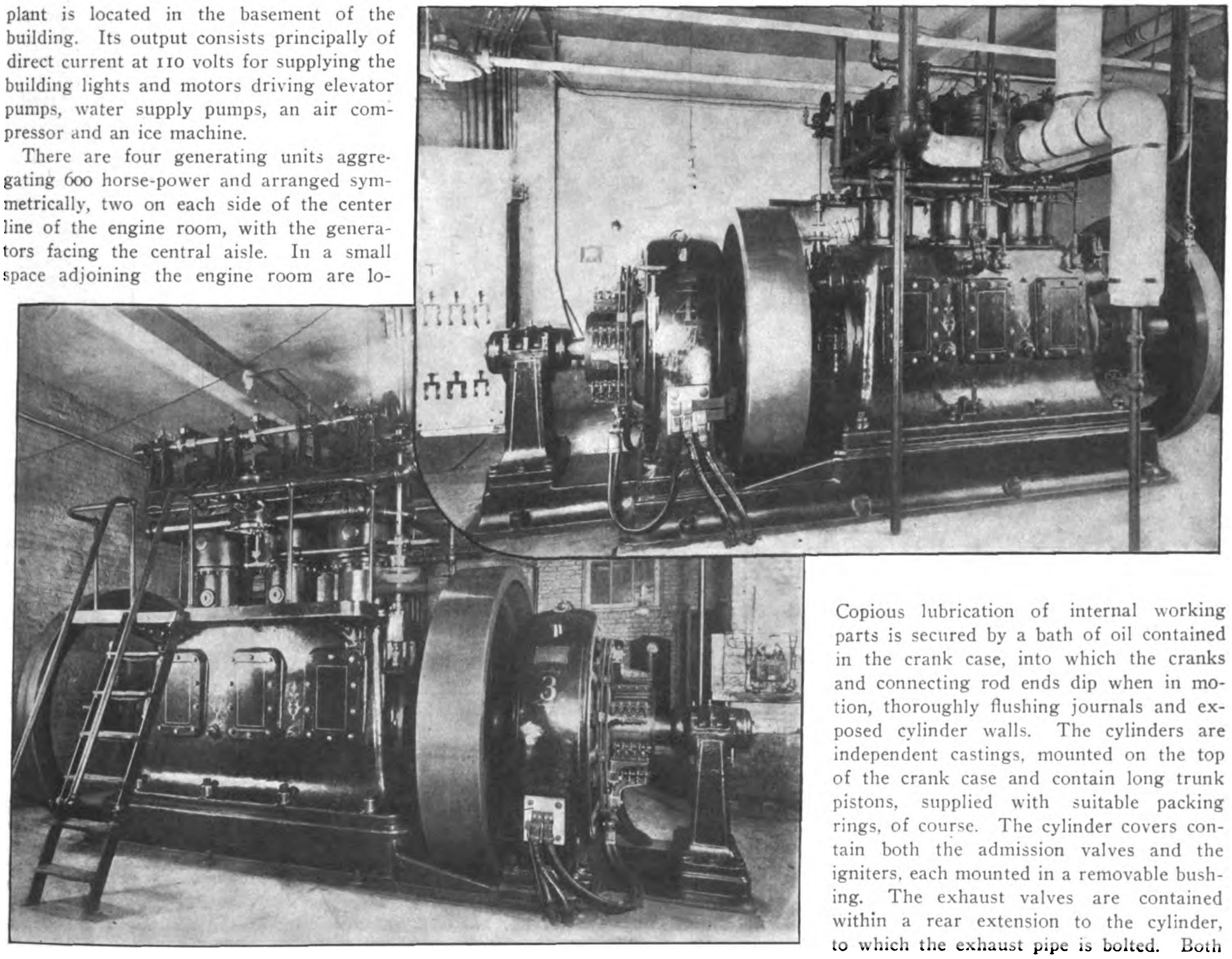
American Electrician.

Vol. XV. New York, April, 1903. No. 4.

AN APPLICATION OF GAS-ENGINES TO ISOLATED PLANT WORK.

POWER EQUIPMENT OF THE KEYSTONE BANK BUILDING, PITTSBURG.

An isolated light and power plant installation of considerable interest has recently been completed and is in successful operation in the Keystone Bank Building, Pittsburg, Pa. The building is located in the center of the business district and contains a large number of offices upon the upper floors in addition to those occupied by the bank on the street floor. The power plant is located in the basement of the building. Its output consists principally of direct current at 110 volts for supplying the building lights and motors driving elevator pumps, water supply pumps, an air compressor and an ice machine.



FIGS. 1 AND 2.—FRONT AND REAR VIEWS OF TWO OF THE GAS ENGINE GENERATING SETS.

There are four generating units aggregating 600 horse-power and arranged symmetrically, two on each side of the center line of the engine room, with the generators facing the central aisle. In a small space adjoining the engine room are located air storage tanks, and a motor belted to an air compressor. Along the opposite side wall stands the switchboard, from which are controlled the generators, motors, and all power and lighting feeders leading to the various local centers of distribution throughout the building. In other parts of the basement is located the remaining machinery necessary for the plant and building service, comprising two motor-driven centrifugal pumps for the elevator system, four motor-driven triplex pumps for furnishing water throughout the building and circulating water for the condenser, and the motor-driven ice machine previously mentioned.

The generating units are Westinghouse three-cylinder gas engines, direct-connected to 115-volt direct-current engine-type generators. Two sizes of units are employed for convenience in accommodating the varying loads encountered at different hours of the day. The two larger units consist of 14-in. x 18-in. 175-h.p. engines and 110-kw. generators; the two smaller ones of 13-in. x 14-in. 125-h.p. engines and 75-kw. generators. The engine and generator of each unit are mounted on a continuous bed-plate which rests on a solid concrete foundation. The units weigh 51,800 and 84,200 lbs. respectively.

The engines are standard Westinghouse machines of the vertical single-acting type. The engine operates on the four-stroke cycle, with a positive scavenging stroke, and since it is single acting, all thrusts upon the bearings are downward. The shaft is solid forged, with cranks set 120° apart, circularly and counterbalanced for the weight of the connecting rod and pistons. Copious lubrication of internal working parts is secured by a bath of oil contained in the crank case, into which the cranks and connecting rod ends dip when in motion, thoroughly flushing journals and exposed cylinder walls. The cylinders are independent castings, mounted on the top of the crank case and contain long trunk pistons, supplied with suitable packing rings, of course. The cylinder covers contain both the admission valves and the igniters, each mounted in a removable bushing. The exhaust valves are contained within a rear extension to the cylinder, to which the exhaust pipe is bolted. Both cylinders and heads are thoroughly water jacketed.

The valve movements of the engine are controlled through two cam shafts, positively driven through gearing from the main shaft. The upper cam shaft also operates a duplicate set of electrical igniters of the make and break type, this second set constituting a reserve. Single beat poppet, or "mushroom" valves control both the admission and the exhaust. They have a vertical movement; the opening is positively effected from the cam shafts, and the seating is by spring pressure. In these engines, as well as all of this and larger sizes, the exhaust valves are water cooled. For this purpose the valve stem is drilled hollow, so that water may be conducted to a series of spray holes on the under side of the valve. This water is conducted to the rod through a flexible hose connection, and escapes into a pocket in the exhaust pipe, from which it is drained.

Automatic speed regulation is secured by means of a centrifugal ball governor, mounted on the vertical rod transmitting motion from the main shaft to the upper cam shafts. This governor controls the quantity of explosive mixture delivered to the cylinder, according to the load requirements, but the quality of the mixture is manually adjusted to the proper constituency for the gas used and is not changed by the governor. Compressed air from the storage tanks is used for starting the engine, one of the cylinders being temporarily isolated for that purpose by a special disengaging gear. This cylinder acts as an air motor at starting; after one or two revolutions the explosive cycle is started, and the air cylinder is then restored to its normal functions as a working cylinder.

The ignition apparatus consists of four cells of storage battery for each engine, two being used for service while the remaining two are being charged. These cells are used in connection with the customary spark coils. Natural gas is used for fuel in this plant. It is obtained from local wells and has a calorific value of approximately 950 B.T.U. per cubic foot.

The four generators are standard Westinghouse engine-type machines, with the armatures mounted upon extensions of the engine shafts. The circular field yokes are split vertically, so that the two halves may be drawn apart horizontally for the inspection or repair of field or armature coils. This feature is of much importance in this plant where headroom is limited and no apparatus for handling heavy weights is available. The generators are compound-wound, and deliver current in parallel to the main bus-bars.

The series field coils are of forged copper conductors of rectangular section provided with flexible leaf-copper terminals. Both the series and shunt coils are well protected against abrasion by a layer of heavy twine. The armature spider also carries the commutator, and is pressed and keyed on the main shaft. The armature coils are form-wound, of course, and the conductors are bars of forged copper, insulated with mica and other materials commonly used for this purpose, and baked before assembling in the slots of the armature core.

The brush-holders and connecting bus-rings are carried on brackets projecting from a guide ring supported in a circular groove in the field frame. The brush rigging is adjusted by means of a vertical worm gear engaging this guide ring and operated by a small hand-wheel. As Fig. 3 shows, none of the brush-holder rigging, excepting the brushes and holders themselves, extends over the commutator, which greatly facilitates the care of the commutator.

The switchboard is of polished white marble and comprises the usual arrangement of generator and feeder panels, with suitable switches, meters and protecting devices. One panel is devoted to each generating unit and the remainder control the various feeder circuits for light and power.

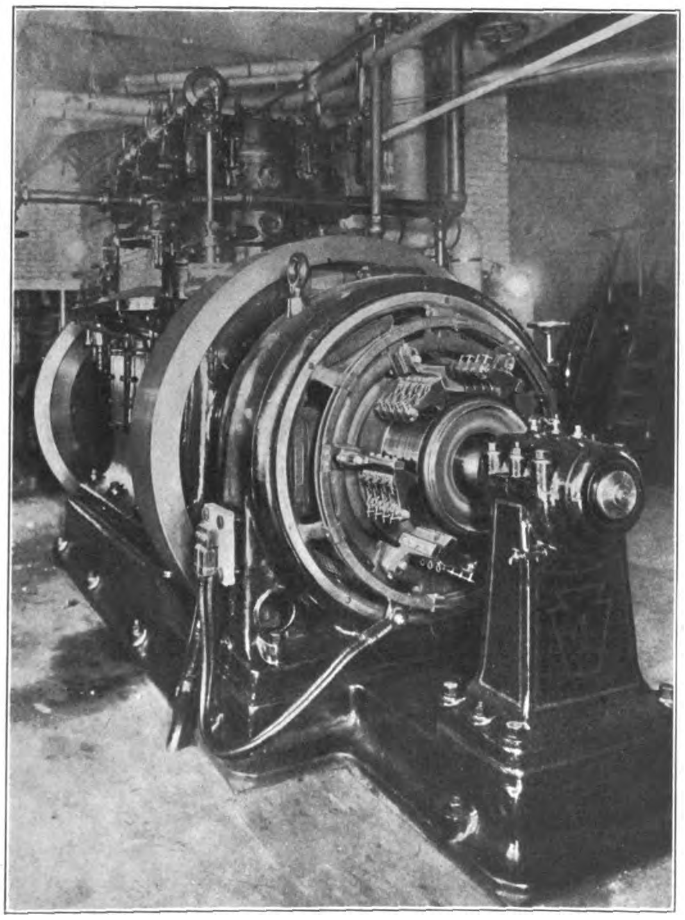


FIG. 3.—SIDE VIEW OF GENERATING SET.

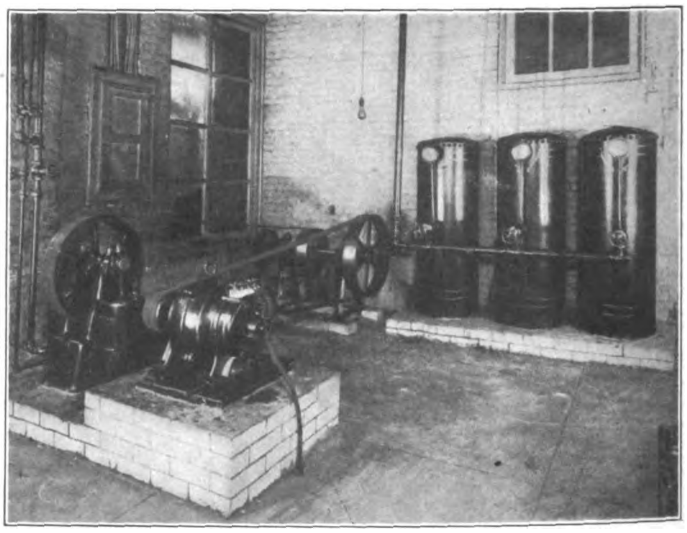


FIG. 4.—MOTOR-DRIVEN AIR COMPRESSOR.

HARVESTING BY ELECTRIC POWER.

BY HAMILTON WRIGHT.

A method of using electric power which may be destined to revolutionize present methods of harvesting grain on a vast scale has been developed in the San Joaquin Valley, California. It has been successfully demonstrated that a combined harvester and thresher with electricity as its motive power will perform the work of a 60-h.p. traction engine at one-fifth the cost for power alone, and one-half the cost for total operating expenses. A large dynamo was recently set up on a dismantled traction engine, electrical connection being provided by an insulated cable which was paid out from a reel as the machine advanced, the dynamo being used as a motor to propel the traction engine. When current was admitted to the motor the big machine started away without a hitch, drawing a combined harvester at a rate sufficient to cut and thresh 85 acres of standing grain a day. A similar harvester drawn by 41 horses would cut an average of 60 acres a day at almost three times the total cost of operating. In the great wheat fields of the Pacific Coast, however, steam has almost entirely superseded animal power. Now electricity bids fair to take the place of steam.

A strong feature of the electrically driven combined harvester and thresher is that with it four men may produce results which have hitherto required the services of a dozen. A motorman, a steerer, a sack-sewer and a general attendant easily attended to the big harvester on its trial trip. Doubtless when a greater degree of perfection in this method is attained three men will suffice, the motorman also steering the machine. It is obvious that an electric traction engine could also haul a harrow, plow, sower, cultivator, etc., and do the work of steam machines built for the various agricultural operations.

A fact perhaps not yet realized is that irrigation and generation of power from the fall of water go together. Not a single drop of water is lost by the utilization of its specific gravity, and when the water issues from the turbine of a power house it may be re-diverted to agriculture. Thus the water which is used to irrigate the land may also furnish power to harvest the crops. It is estimated that the running streams of California alone will supply 840,000 horse-power. Of this amount the fairly large quantity of 125,000 horse-power has already been utilized.

TRANSPOSITION AND RELATIVE LOCATION OF POWER AND TELEPHONE WIRES.

BY P. M. LINCOLN.

The extraordinary sensitiveness of the telephone receiver makes this instrument peculiarly susceptible to electrical disturbances. One authority states that the energy used in a 16-c.p. incandescent lamp is sufficient to produce an audible sound in thirty billion receivers. The methods, therefore, of shielding telephone wires from the inductive effects of neighboring wires become important. Particularly is this true in the case of a telephone line paralleling a high-tension transmission line, where the inductive disturbances are apt to be large, and uninterrupted service on the telephone line important.

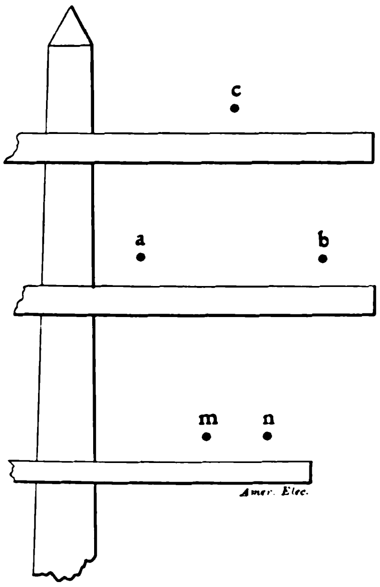


FIG. 1.—THREE-PHASE TRANSMISSION LINE.

The remarks and discussion in this "Introduction to Discussion" apply particularly to telephone lines paralleling high tension lines, but comments hereon need not be restricted to such cases.

There are three ways in which disturbing current in telephone circuits may be caused by the high-tension circuit, by electromagnetic induction, by electrostatic induction, and by leakage. It is the first two causes of disturbances which will claim particular attention in the following discussion.

Electromagnetic induction may be briefly described as a transformer action. In Fig. 1 let *a*, *b* and *c* be the conductors of a three-phase line, and *m* and *n* the two wires of a parallel telephone circuit; *a* and *b* may then be regarded as the primary and *m* and *n* as the secondary of a transformer. The e.m.f. in the circuit *m*, *n*, will depend, among other things, upon the amount and frequency of the current in the inducing circuit. By transposing *m* and *n* in the well-known manner, the e.m.fs. set up in one part of the telephone circuit will be neutralized by equal and opposite e.m.fs. set up in other parts. Thus, the electromagnetic effects between *m* and *n* may be entirely neutralized by transposing the telephone wires only, regardless of whether the transmission wires are transposed or not. It may be well to note, however, that while the e.m.f. *between* the two telephone wires may be reduced to zero by properly transposing the telephone wires only, the e.m.f. between the two telephone conductors considered as one side of a circuit and the earth as the other, can be reduced to zero only by transposing the power wires. This point is of little importance, however, as any electromagnetic e.m.f. between the telephone wires and ground is entirely overshadowed by the electrostatic effects.

Electrostatic effects will also take place in *m*, *n*, due to transmission circuit *a*, *b*, *c*. If the conductor *a* has a minus charge, for instance, it will induce a certain plus charge on *m* and a smaller plus charge on *n*, on account of *n*'s greater distance from *a*. If now the minus charge be removed from *a*, current will flow from *m* to *n*, proportional to the difference in the amounts of these charges. The electrostatic influence of *b*, being opposite *a* in sign, will reinforce the action of *a*. Transposition of the telephone wires will have the effect of neutralizing this tendency of setting up electrostatic currents between *m* and *n*. It is important to note that a system of transpositions designed to correct electromagnetic induction between the wire will also be correct for electrostatic induction.

Considering the comparative electromagnetic and electrostatic disturbances in a section of untransposed telephone line, it may be interesting to observe that the first is in the nature of a constant potential effect, and the second of a constant current effect. It is evident that induced electromagnetic e.m.f. is constant as long as the inducing current is constant. As for the electrostatic effect, it is evident that the amounts of the induced charges on *m* and *n*, and therefore the electrostatically induced current between them, will not become appreciably reduced until the current flowing between *m* and *n* makes a difference of potential between them appreciable, compared with the inducing difference of potential. With telephone receivers of varying resistance, therefore, the ampere-turns in the receiver due to electromagnetic induction are practically constant, while those due to electrostatic induction increase with number of turns and therefore the resistance of receiver. The electrostatic and electromagnetic effect become roughly equal with an arrangement shown in Fig. 1, when *a*, *b*, *c* is a line carrying 50 amperes at 20,000 volts, and the telephone circuit contains a total resistance of 1,000 ohms, including receivers.

The bridged telephone has almost universally taken the place of the series instrument for all telephone work. The series telephone is particularly objectionable for use on a circuit in which static induction takes place to any great extent. The reason for this will be seen by an inspection of Fig. 2. The telephone wire *m* has between *A* and *B* a positive charge induced and between *B* and *C* a negative charge. There is, therefore, at the transposition point *B* a flow of current from one section of *m* to the other. If now a series telephone be placed in series with *m* at *B*, it not only gets the benefit of this charging current between the two sections of *m*, but it also creates a difference of potential and, therefore, disturbing currents in telephones at *A* and *C* as well.

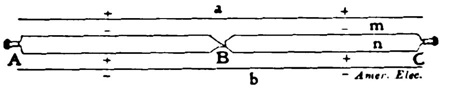


FIG. 2.—TRANSPOSED LINES.

Although a proper system of transposition will prevent the establishment of an induced e.m.f. between the two telephone wires themselves, it does not necessarily prevent a difference of potential between the two wires and the earth. In a properly transposed system, each telephone wire is the same average distance from each power wire. The potential, therefore, which the telephone system tends to assume from the static induction of the power wires is that of the neutral point of the power system. By neutral point is meant that point between which and each of the power wires the average e.m.f. is the same. Under normal conditions this neutral point is at ground potential. If, however, leakage takes place from one of the power conductors to ground, this neutral point will differ in potential from the ground and the amount of this difference becomes greater as the resistance of the leak becomes less. In a three-phase system, should the resistance of this leak become zero, the maximum difference of potential between the neutral point and ground will occur and this will be 58 per cent of the power circuit e.m.f. In a 20,000-volt system, for instance, there may exist a difference of potential of nearly 12,000 volts between the neutral point and ground.

When the neutral point of the power line differs in potential from the ground, an electrostatic difference of potential tends to exist between the telephone wires and earth, and will exist if the insulation of the telephone circuit is perfect. The amount of this electrostatic potential between the telephone circuit and the earth will depend upon the relative capacities between the power and the telephone lines, on one hand, and between the telephone line and the earth, on the other. The power and telephone lines may be considered as opposite plates of one condenser and the telephone line and ground as opposite plates of another condenser. These two condensers being in series, they will distribute the total e.m.f. in inverse ratio to their capacities. With usual construction, the capacity between telephone line and ground will not be less than that between telephone and power wires, so that the potential of the telephone wires above that of the ground will be equal to at least one-half the potential of the power line neutral point above the ground. A grounded power line may thus cause a potential between the telephone wires and ground which will reach well into thousands of volts, and even a bad insulator may cause such an e.m.f. running up to hundreds of volts.

In this connection it is significant to note that in the great majority of cases the telephones become inoperative when a ground occurs on the power lines. Is it any wonder? How many telephone lines are built to stand up under a strain of even 1,000 volts, let alone 5,000 or 10,000 volts to ground? It is hardly necessary to point out the path of the disturbing currents. The first voltage strain comes not between telephone wires, but between the two wires and ground. A break down of its insulation, either partial or complete, occurs at some point, and the wire to which the break occurs discharges to ground either partially or completely, and the other wire must discharge *through the telephones* to ground.

The points, therefore, which deserve careful consideration in the installation and operation of a telephone line when it is to be operated in proximity to a high-tension transmission line are insulation, transpositions, the use of bridge telephones instead of series telephones, and making the static capacity of the telephone wires to ground as great as possible, and the capacity to power wires as small as possible. Insulation is put first as being the point of first importance. A ground on the transmission line is going to cause either excessive e.m.f. or other trouble on the telephone line. There is no allowable reason why the telephone circuit should not transmit speech properly, even if it does differ in potential from the ground. But to obtain this result, disturbing currents from the line to earth must be prevented by perfect insulation. When it is realized that the potential between the telephone line and ground may be as high as 30 per cent of the potential between power wires, the importance of insulation is better understood.

By insulation is meant the insulation throughout the entire line. There is little use in providing glass insulators for pole supports capable of standing a voltage of 15,000 or 20,000 and then inside buildings attaching the telephone wires directly to woodwork which may be damp, or to an instrument mounted on a damp brick wall. Above all, there is no use in putting up a line which may be able to stand a test of 15,000 or 20,000 volts, and then attaching to this same line a lightning arrester which will break down at 300 volts, as the standard telephone lightning arrester is expected to do.

When providing high-tension insulation for the telephone line, the insulation of the man using it should not be forgotten. This insulation of the telephone used is advisable, not only to protect him from the induced voltage but also to protect him in case of a cross with the power line. The induced voltage is not so dangerous as its amount would indicate because the current is limited to that of a condenser consisting of the power line acting as one plate, and the telephone line as the other. It may be noted that the telephone insulation is subjected to high strains only when the power line is grounded or heavily unbalanced statically. This is just the time, however, that uninterrupted service of the telephone line is apt to be of the utmost importance.

The necessity of transposing the telephone line is almost so apparent as not to need comment. Otherwise continuous disturbances will exist, due both to electromagnetic and electrostatic effects. So far as the telephone line is concerned, transposition of the power wires is not so important. An untransposed power line cannot induce either electrostatic or electromagnetic effects between two transposed telephone wires, but only between these two wires and the earth. The amount the statically balanced untransposed power line can elevate the telephone wires above the earth potential is small compared to the effect of the power line when statically unbalanced, whether transposed or untransposed. If the telephone line is insulated to meet the worst conditions, it will be ample to meet the normal condition of an untransposed power line.

The advantages of the bridged over the series telephone are so well known that the reason before mentioned for using a bridged instead of a series instrument is simply throwing another shovelful of earth on the grave of the series instrument.

When one realizes that with the usual construction as shown in Fig. 1, and line e.m.fs. of 50,000 to 80,000 volts, there may be an elevation of 20,000 to 25,000 volts in the potential of the telephone wires above ground, he begins to cast about for some method of reducing this potential. The total voltage between the neutral point of the power wires and earth may be considered as taken up across two condensers, one consisting of the power and telephone wires, and the other the telephone wires and earth. To decrease the possible difference of potential between the telephone wires and the ground, therefore, one must either decrease the capacity of the power-wire-telephone-wire condenser, or increase the capacity of the telephone-wire-earth condenser, or both. This may be accomplished by increasing the distance between the power and the telephone wires, and decreasing the distance between the telephone wires and the earth. If the same supporting structure be used, there is a limit to which this can be carried, at which the possible voltage between telephone wires and earth may be still prohibitive. The capacity of the telephone-wire-earth condenser may be still further increased by bringing the earth nearer to the telephone wires, instead of the telephone wires to earth; that is, by running one or more grounded wires in close proximity to the telephone wires. By this means the capacity of the telephone-wire-earth condenser may be increased so as to bring the possible potential between the telephone wires and the earth within limits where it may be taken care of with safety.

[The foregoing is a paper intended as an introduction to a general discussion at the last meeting of the American Institute of Electrical Engineers.]

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Underground Cables.—It is good practice to break the lead sheaths on high-voltage lines and insert insulating joints at intervals of possibly 3,000 feet and also to ground the lead sheath on each section in two or three places to guard against electrolysis.—*Exchange.*

THE TESTING OF INSULATORS.

BY F. O. BLACKWELL.

There are certain facts which must be considered if correct deductions are to be made from insulator tests. For instance we cannot test each insulator with a give number of volts continuously as it would be in service. As is well known, all insulating materials are most apt to break down under long-applied electric stress. The prepared cloth wrappings used on the windings of electrical machinery will stand instantaneously two or three times the potential that they will carry continuously. Glass and porcelain are not affected by time to the same extent as organic materials, but both may be punctured by long continued applications of lower pressures than they have withstood in a test.

The shape of the potential wave also has a pronounced effect in breaking down insulation. A wave may be either flat topped or peaked, so that the maximum instantaneous potential may be much less or greater than that of a sine wave of the same mean square potential. For the same potential as read by the voltmeter, the maximum instantaneous potentials might differ as much as two to one.

In air, the maximum point of the wave determines the distance the current will "jump." Different generators, or even the same generator under different conditions of load, will show widely varying arcing distances for the same effective or $\sqrt{\text{mean sq.}}$ potential. Insulating materials, being affected by time, show in their ability to resist puncture that the average potential of the wave is more important than the maximum.

It is not safe to assume either the potential indicated by the voltmeter or that indicated by the air-gap as the true potential for determining the insulating value, as it is somewhere between the two. Moisture in the atmosphere also affects the arcing distance. In fog a given potential will jump 25 per cent farther than under ordinary conditions. Of course, if the altitude is high and the air more rarefied, the arc will also jump a greater distance.

The alternators generally used for long-distance transmission plants give very nearly a sine wave and therefore the testing generator should be one which will give a sine wave under all conditions. It is not sufficient to do so at full potential and no load, as tests are made with all degrees of excitation and with both leading and lagging currents.

The armature reaction should be as small as possible, which means that the generator should be much larger than would ordinarily be thought necessary. It is also desirable to have a high reluctance in the magnetic circuit in order to secure stability when running with weak field excitations, and permit control with a reasonable amount of field resistance.

There should be but one transformer used to step up to the highest potential required and its reactance should be as low as possible. A number of transformers in series is particularly bad, as it gives poor regulation and leads to great uncertainty as to the actual potential to which an insulator is being subjected.

I have known testing sets with transformers in series and a generator of poor regulation to vary widely in the relation of the generator volts and the length of the spark gap due to change of wave form with different magnetic saturations of the apparatus and different numbers of insulators and consequently various capacities on the testing circuit. The only certain way to determine the real potential is to have a step-down instrument transformer on the high potential circuit.

Assuming that insulators are to be passed upon for a specific transmission plant, they should first be inspected to see that they are free from cracks, bubbles or pits that will impair their strength or in which mositure can lodge. If of porcelain, the glaze should cover all the outer surfaces. The glaze is of no insulating value in itself, but dirt sticks to unglazed surfaces. Experience has shown that porcelain insulators that are not absolutely non-absorbent are worthless. The best porcelain shows a polished fracture like glass. If there is any doubt about the quality of the porcelain in this respect, it should be broken into small pieces, kept in a hot, dry place for some time, weighed and immersed in water for a day. When taken out of the water the weight should be the same as at first. A puncture test should be made by setting the insulator in a cup of salt water, filling the pin hole also with water and slowly increasing the potential between the top and bottom until the desired test potential is reached or the insulator either punctures or shows leakage over the surface.

If an insulator is built up of several parts, each part should be able to withstand an e.m.f. greater than it will have to sustain when the complete insulator is tested. If it is to be tested for 100,000 volts and is made in two parts, each part might, for instance, be tested with 70,000 volts. The object of this is to have the weak parts rejected before they are assembled. A fair puncture test for an insulator is twice the potential for which it is to be employed, applied between the head and the interior for one minute. For example, the insulators for a 50,000-volt line should each stand 100,000 volts. As the potential from any wire to ground on a 5,000-volt three-phase system would only be about 30,000 volts, a 100,000-volt test gives a factor of safety of nearly three and one-half to one. If one branch were grounded, as sometimes occurs in practice, the factor of safety would be but two to one. A one-minute test is not so severe as a continuous application of an equal potential, but insulators that have passed this test stand up well in service.

New types of insulators should be mounted on iron pins and tested both wet and dry, to determine the potentials which will arc over them. The dry test is of little value, as the potential at which the arc jumps from the head to the pin can be predetermined by measuring the shortest distance between them and referring to a curve of arcing distances in air. In a wet arcing test, a stream of water from a sprinkler nozzle under a pressure of at least 50 pounds to the inch should be played on the insulator at an angle of say 30 degrees from the horizontal. This will be similar to the condition which exists in a rain and wind storm. The insulator should not arc over from the wire to the pin at less than the potential which will exist in service between any two conductors.

In no case should wooden pins be relied on for insulation, as their value is only temporary. All wooden pins in time become dirty and absorb moisture. Eventually they burn off unless the insulator is good enough to have been used with an iron pin. If an insulator is going to fail, it is better to have it do so at the start and not interrupt the service by breaking down perhaps years afterwards.

In addition to the electrical tests, it is well (if the insulator is of a type that seems to require it), to try samples for mechanical strength. When mounted on pins the insulator should stand a side strain of at least ten times the pressure exerted by the air on the conductor with a wind velocity of, say, 100 miles an hour. It should also be able to slip the conductor through the tie wire should the former break. These tests are particularly desirable with built-up insulators in order to be certain that the parts will not separate. With such insulators, it would also be well to test them in tension along the axis of the pin. In transmission lines crossing depressions, such an upward pull is not infrequently exerted on the insulator.

[The foregoing is a paper intended as an introduction to a general discussion at the last meeting of the American Institute of Electrical Engineers.]

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Power from Drainage.—The water of the Chicago drainage canal near Joliet develops electric power which is transmitted to Chicago and used to pump water from the Chicago River into the Illinois-Michigan canal. Thus Chicago's waste in water is returned in the shape of electric energy.

CIRCUITS FOR THE TRANSMISSION AND DISTRIBUTION OF ELECTRICAL ENERGY.

BY A. S. M'ALLISTER.

While the fundamental facts concerning the advantages to be derived from operating transmission circuits at relatively high potentials were well appreciated even before the period of the infancy of the electric lighting industry, with the direct-current system a limit to the increase in the circuit e.m.f. was soon set by the maximum voltage which could be successfully applied to the receiving apparatus. An improvement was found in the three-wire system, which doubled the limit of e.m.f. and resulted in practically quadrupling the economic area of operation. An extension of this method led to the installation of the five-wire system with accompanying increase in the circuit e.m.f.

The principal advantage possessed by alternating over direct current lies in the fact that the line e.m.f. may be selected without regard to the e.m.f. of the receiving apparatus, and may be given a value limited only by the strength of the insulation of the circuits and transforming devices.

With reference to the voltage of transmission circuits, the following fact is worthy of remembrance: Although the weight of copper requisite for the transmission of a given amount of energy a given distance at a certain loss varies inversely as the square of the e.m.f., and the weight of conducting material necessary for transmitting a given amount of energy at a certain e.m.f. with a given loss varies as the square of the distance, if there be assumed a certain outlay in cost for conducting material and a certain energy loss in the line, the distance to which a certain amount of energy can be transmitted varies simply as the e.m.f. varies. As proof of this fact, if the total length of transmission circuit be represented by L and the cross-section of the wire by A, then the cost of the conductor. will be $C\ L\ A =$

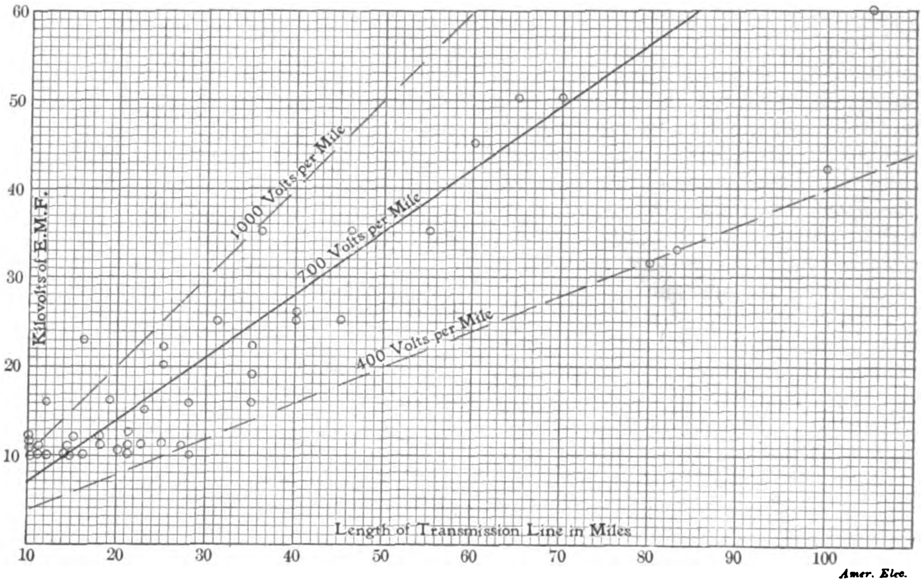


FIG. I.—SELECTION OF E.M.F. FOR TRANSMISSION EQUIPMENTS INSTALLED.

D, which is constant. The loss in transmission will be $I^2 R = W$, also constant; and the power transmitted will be $I E = P$, also constant. Obviously, $I = \frac{P}{E}$; and as $R = \frac{L}{AK}$ and $A = \frac{D}{CL}$, $R = \frac{L^2C}{KD}$. The loss in transmission (W), then, is equal to $\frac{P^2}{E^2} \times \frac{L^2 C}{KD}$, from which it is evident that $E^2 = L^2 \times \frac{P^2C}{WKD}$. As P, C, K and D are all constants, E^2 and L^2 (and consequently E and L) must obviously vary in the same degree.

It is evident that many determining elements enter into the selection of the e.m.f. for a given installation which the above equations do not cover. An examination of the selection of e.m.fs. for almost all of the principal transmission systems now installed in this country, ranging from 10 to 100 miles, shows that the selected e.m.f. varies between the values of 400 and 1000 volts per mile (see Fig. 1.) These plants cover all classes of transmission. The relatively small variation of volts-per-mile from a mean of 700 for so wide a range of service is indeed striking.

Because of the loss of energy from the formation of corona and electric discharges through the air at the extremely high potentials, and in a slight degree, more especially in the past, the difficulty of securing successful insulators for such potentials, a temporary maximum limit of 60,000 or 80,000 volts is placed upon the e.m.f. of transmission systems. In cases, therefore, where it is desired to transmit over a distance greater than 115 miles, an e.m.f. of less than 700 volts per mile must be chosen in the present state of things.

Although of all possible transmission systems the single-phase requires the least number of conductors and, on the basis of equality of maximum e.m.f. to the neutral point, the single-phase is the equal with reference to the cost of conductors of any polyphase system, practically all of the existing transmission circuits are of the polyphase type, chiefly because of the facts that polyphase generators are less expensive in construction and more economical in operation than single-phase machines, and, for the purpose of power distribution, polyphase motors and synchronous converters are far superior to single-phase machines. Of all polyphase circuits operated with a given maximum measurable e.m.f. between lines, the three-phase system is the most economical with reference to the cost of conducting material; which accounts for the fact that, with very few exceptions, all transmission circuits are of the three-phase type.

That all symmetrical transmission systems show the same economy of conducting material irrespective of the number of phases, when compared on the basis of equality of maximum e.m.f. to the neutral point, can be proved as follows: Let N = the number of phases (and conducting wires); R = the resistance of the total mass of conducting material, all wires considered being in parallel; E = the e.m.f. to the neutral point, and P = the energy transmitted. Then NR = resistance per wire; $\frac{P}{N}$ = energy per phase, and $\frac{P}{NE}$ = current per wire. Representing the current per wire by I, the loss in transmission is,

$$\Lambda \ R = \left(\frac{P}{NE}\right)^2 N^2 R = \frac{P^2}{E^2} R,$$

which is obviously independent of the number of phases.

For all systems in which the measurable maximum e.m.f. is twice the e.m.f. from a single conductor to the neutral point, the cost of conducting material for transmitting at a given loss is the same. In this class fall the two-wire (single-phase), four-wire (two-phase), six-wire (six-phase), and other systems in which the number of phases is an even one. An inspection of Fig. 2 will show that in the three-phase system the measurable e.m.f. is only

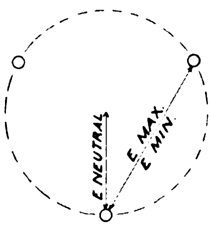


FIG. 2.—E.M.FS OF THREE-PHASE CIRCUITS.

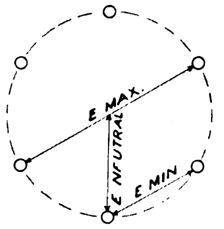


FIG. 3.—E.M.FS OF SIX-PHASE CIRCUITS.

$$2\,E \cos \tfrac{1}{2}\left(\frac{180}{N}\right) = \sqrt{3} \times E,$$

or 1.732 times that from one conductor to the neutral point. On the basis of equality of measurable e.m.f., therefore, the three-phase system requires $\left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4}$ as much conducting material as any system in which the number of phases, N, is even, since the conducting material varies inversely as the square of the e.m.f. for any given system. The calculations recorded in Table I show that a higher conductor efficiency is obtained in each case when N is odd than when it is even, and that the smaller the value of N the higher the efficiency will be. Since N, when odd, cannot be less than three, the three-phase is of all systems the most economical.

Table I.—Relative conducting material required for different transmission systems.

Number of phases (wires)	On basis of minimum e.m.f.		On basis of maximum measurable e.m.f.		
	E_{min}	Conducting material	E_{max}	E_{max}	Conducting material
N	$2\,E \sin\left(\frac{180}{N}\right)$	$\left(\frac{E_{min}}{2}\right)^2$	$2\,E$	$2\,E \cos \frac{1}{2}\left(\frac{180}{N}\right)$	$\left(\frac{E_{max}}{2}\right)^2$
2	2.0000	1.000	2.0000	.....	1.000
3	1.7320	.750	.....	1.7320	.750
4	1.4142	.500	2.0000	.....	1.000
5	1.1756	.346	.....	1.9022	.905
6	1.0000	.250	2.0000	.....	1.000
7	.8678	.188	.....	1.9500	.950
8	.7654	.146	2.0000	.....	1.000
9	.6840	.117	.....	1.9696	.969

While as regards the desirability of obtaining economy in cost of conducting material, the problem of determining the proper circuits for the distribution of electrical energy at the end of a transmission line is quite similar to that connected with the transmission circuits, factors other than economy enter into this portion of the problem, which must be carefully considered before any attempt is made at a definite solution.

The present year witnesses the trial for the first time in this country of several methods of applying alternating-current motors to electric traction. For the propulsion of electric locomotives and street cars, the present state of the art, however, dictates the use of series-wound direct-current motors, to supply power to which nothing has been devised that is more satisfactory than the polyphase synchronous converter. Elevator and crane motor service is similar in many respects to traction work, and the problem connected therewith can best be solved in a similar manner, although many alternating-current equipments are in successful use for these purposes. In addition to the above named classes of service, for each of which polyphase currents are well adapted, provision must be made for lighting service, which is at present essentially a single-phase load, and in all probability will remain so.

In supplying power to incandescent lamps, the regulation of the delivered e.m.f. is of paramount importance, since a variation of e.m.f. of one per cent produces in general from five to six per cent change in the candle-power, and a fluctuating e.m.f. is detrimental to the life of the lamp filaments. Great difficulty is experienced in maintaining constant e.m.f. at the terminals of lamps which are connected to the same system with induction motors, and the fluctuations of the e.m.f. become quite noticeable when motors are thrown into and out of service, even though they be started up without load and the starting current be kept at its minimum value by the insertion of resistance in the secondary circuits, or by the use of auto-transformers for lowering the e.m.f. at the primary terminals. And the lagging current taken by an induction motor, by reason of its effect upon the line impedance, especially upon the inductive component of such impedance, causes a large drop in the delivered e.m.f.

Since, at a given slip, the torque exerted by an induction motor varies as the square of the impressed e.m.f., these fluctuations of the e.m.f. of the distributing circuits are detrimental to the performance of induction motors connected thereto, but the effect is less noticeable at the motors than at the lamps; a decrease in e.m.f. at the motor terminals results in a relatively small decrease in rotor speed and a slight increase in the current taken by the motor.

When the lighting load is divided unequally among the phases, that phase which carries the least load will show the highest e.m.f. The effect of connecting an induction motor or other polyphase apparatus to such an unsymmetrically loaded system is to cause the machine to obtain the major portion of its energy from the phase having the highest e.m.f. and thus to tend to adjust the e.m.fs. to equality. In cases of extreme unbalance, a polyphase machine may even receive from one phase energy more than requisite for its load and return the excess power to the line by way of another phase. Obviously, this characteristic is of advantage with reference to the lights, but it necessitates, in all cases, in the windings of the motor an excess of heat loss above that corresponding to the load on the machine, and, as a general statement, it may be said that the best machines are the ones that suffer most in this respect.

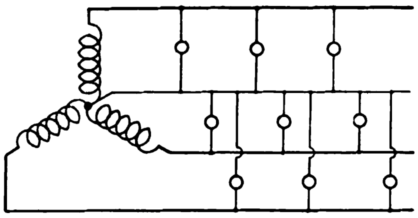


FIG. 4.—FOUR-WIRE, THREE-PHASE CIRCUITS.

For the operation of lamps from polyphase distributing circuits many engineers advocate the use of the four-wire three-phase system, in which each lamp is connected between a common neutral wire and one of the three main leads (Fig. 4); some claim advantages for the independent circuits of the two-phase system (Fig. 5), sometimes even operated three-wire fashion in each phase, as shown by Fig. 6; while others find the three-wire two-phase system more economical as to the number of conductors required (Fig. 7). All of these systems, however, possess the obvious disadvantage of being subject to variations of e.m.f. when motors are operated from the same circuits, on which account it is most frequently found desirable to install separate circuits for the motor load. A unique method of overcoming these difficulties and of improving the economy of distributing systems has been proposed by Dr. Frederick Bedell. This method involves the simultaneous transmission of currents of differing frequencies over the same conductors.

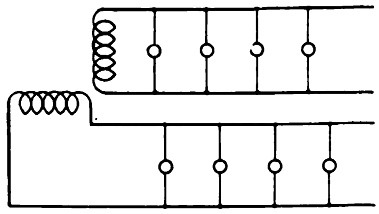


FIG. 5.—FOUR-WIRE, TWO-PHASE CIRCUITS.

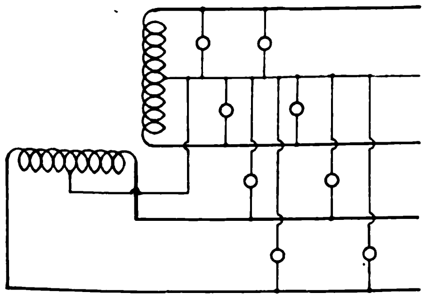


FIG. 6.—FIVE-WIRE, TWO-PHASE CIRCUITS.

When a direct and an alternating current are passed simultaneously through a conductor, at the instant when the two currents flow in the same direction the actual current in the conductor is the sum of the two individual currents, while during the remaining portion of the time, the line current is the difference of the two. It might seem that the combined effects of the two currents would be to produce a resultant value equal to that of the larger current. This, however, is not the case, since the effect when the two currents are opposed is not equal to that when the two flow in the same direction, so that the effective value of the resultant current, while less than the sum of the two, is greater than either of the component superposed currents and is, in fact, equal to the square root of the sum of the squares of the two currents.

Let I equal the constant value of the direct current, and select any instantaneous value of the alternating current, calling it i. Now, for each increment of time when i is of the same sign as I, there is a corresponding equal increment when they are opposite in sign. In the former case the effect is the same as though the actual current were $(I + i)$, and in the latter case as though the current were $(I - i)$, and since the effective value of a current is determined by the square root of the mean square of the instantaneous values, the effective resultant in this case is

$$I_e = \sqrt{\frac{(I + i)^2 + (I - i)^2}{2}} = \sqrt{I^2 + i^2},$$

From this equation it is plain that each current has upon the conductor an effect the same as though it flowed alone. The same relation obviously holds true when I is an alternating current of any frequency different from that of i, since the assumption made as to phase and opposition applies in this case also.

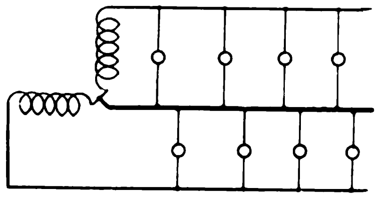
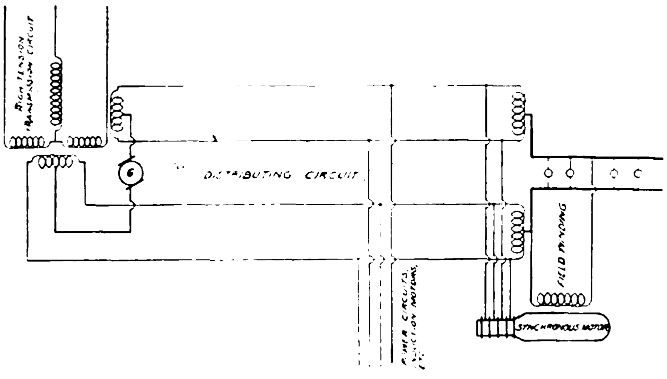


FIG. 7.—THREE-WIRE, TWO-PHASE CIRCUITS.


HIGH TENSION TRANSMISSION CIRCUIT
G
DISTRIBUTING CIRCUIT
POWER CIRCUITS, INDUCTION MOTORS, ETC.
FIELD WINDING
SYNCHRONOUS MOTOR
FIG. 8.—DIAGRAM OF INTERCONNECTED CIRCUITS.

If the two currents have the same effective value, the conducting material necessary for transmission at a certain loss of energy will be just one-half that required for a single current equal in value to the sum of the two. If I represents the value of each current, and R, the total resistance of the circuit, then the loss in transmission will be $I_e^2 R = (I^2 + I^2) R = 2 I^2 R$. If a single current of value $2I$ flowed, the loss would be $4I^2R$. Hence, for equal losses under the two conditions of operation, the resistance in the first case would be twice that in the second, or, for the composite transmission the conducting material need be but one-half of the cross-section required for that carrying a single current.

Since each current produces an effect regardless of the existence of the other, a receiving apparatus supplied with current at one frequency will in no way be affected by the flow of current at the other frequency to an independent receiver. Fig. 8 is a diagram of one system of interconnected circuits for the independent operation of receiving apparatus supplied with currents of different frequencies transmitted simultaneously over the same distributing circuits. For motor work and similar service, current at the frequency of the high tension transmission circuit is supplied through lowering transformers at the proper e.m.f. for the operation of the polyphase receiving apparatus.

The generator, G, is shown in the diagram as a direct-current machine, the current from which is sent by way of taps at the neutral points of the low-potential windings of the two phase-changing transformers, and received at any convenient location along the route of the distributing circuits by way of two similarly disposed taps. It is not essential that the generator shall be of the direct-current type, though synchronous motors, etc., can most conveniently be operated when there is available a suitable supply of direct current. The generator can be driven by a polyphase motor and its e.m.f. regulated independently of any fluctuation of the e.m.f. of the supply.

With the equipment as here suggested, a load on one circuit has no effect whatever upon the e.m.f. of the other, except to such an extent as an excess of temperature due to heat loss from one current may cause a slight increase in the resistance of the conductors. The lights will not fluctuate from a change in the number of motors in operation, nor will the separate windings of the motors be subjected to inequality of currents due to lack of balance in the loads on the distributing circuits. The e.m.f. of the polyphase circuit can be of any value desirable for the operation of motors while that of the other circuit can be selected with due regard to the e.m.f. suitable for the lamps, though with circuits interconnected, as shown by Fig. 8, proper precautions need to be taken that the motor e.m.f. be less than that value which would subject the insulation of the lamp circuit to excessive strain in event of a ground on the distributing circuits.

If the dynamo, *G*, be an alternating-current generator having a frequency different from that of the high-tension transmission circuit, the superposed single-phase current may be of an e.m.f. limited in value only by the insulation of the polyphase motors, while transformers of proper ratio may be used to reduce the single-phase e.m.f. to a value suitable for the lamp circuit. This latter arrangement possesses other advantages, since a frequency as low, perhaps, as 25 cycles is desirable for the transmission circuits and for any synchronous converters which may be operated therefrom. Arc lamps, however, require a frequency above 40 cycles, and incandescent lamps, unless possessing heavy filaments, show a fluctuation in brilliancy when the frequency is much below this value; Nernst lamps show increased life with increased frequency. In the composite system of distribution the primary frequency can be placed at a low value dictated wholly by the generating apparatus, transmission circuits and polyphase receivers, while that of the superposed current can be given a value as high as desirable for the single-phase lighting load.

A REMARKABLE ENGLISH ENGINE.

One of the most remarkable performances thus far recorded of a steam engine of moderate size, was made by an engine built by Easton & Co. (Limited), of Erith, Kent, England, for the British Xylonite Company's Brantham Works, near Manningtree. The tests were made by Prof. Ewing, of Cambridge University, with the cooperation of the resident and consulting engineers of the Xylonite Company and representatives of Easton & Co.

The engine is one of a pair of engines built by Easton & Co., each indicating 300 horse-power, and employed to drive three-phase generators, which supply current for distribution of power over the Brantham works. It is a horizontal tandem two-cylinder compound, double-acting in both cylinders, with a Schmidt reheater in the receiver between the two cylinders. The reheater acts by transferring a portion of the superheat of the highly superheated live steam to the steam which has done duty in the high-pressure cylinder. Steam is supplied from a Lancashire boiler at a pressure of 140 lbs. per square inch, and is superheated in an independently fired Schmidt superheater to nearly 800 degrees Fahrenheit. It reaches the engine at a temperature of about 750 degrees, but before admission it gives up about 170 degrees of this superheat to the steam in the receiver, and consequently enters the high-pressure valve chest at a temperature of about 580 degrees Fahrenheit. The engine has four double-beat lift valves on the high-pressure cylinder, two for admission and two for exhaust. The admission valves are worked from an eccentric controlled by a powerful shaft governor. Each of the four valves is opened, as well as closed, positively by means of a rocking lever. The low-pressure cylinder has four Corliss valves. There is a jet condenser with a vertical air-pump driven by means of a bell crank lever from the tail-rod of the low-pressure piston. The cylinders are 15 ins. and 24 ins., and the stroke 28 inches. The speed is 140 revolutions per minute.

TABLE I.—Summary of Tests.

Trial No.	Indicated horse-power.	Effective electrical output, kilowatts.	Electrical Horse-power.	Ratio of E.H.P. to I.H.P.	Number of pounds of steam. Total per hour.	Per I.H.P.	Per electrical unit.
I	312	190	255	.82	2925	9.4	15.4
III	239	143	192	.80	2150	9.0	15.0
II	175	97	130	.74	1670	9.5	17.2
IV	47	3½	4.8	..	975	..	...

For the purpose of the trials, arrangements were made to take the electrical load on a non-inductive resistance. Three large barrels were kept full of acidulated water, and were connected by a lead plate forming the neutral point. Lead plates dipping into this water formed the terminals of the three mains, and the three phases were kept balanced by adjusting the depth of immersion and the amount of acid in each barrel. Ammeters and voltmeters were provided on all three phases and their readings were systematically noted throughout each run. The phases being balanced, the electric power was found by taking the product of the mean current in the three mains by the mean volts across each three pairs of mains and multiplying by the square-root of three. The readings of effective electrical output, determined in this way, were checked by those of a wattmeter, which received its current from one phase and gave results in good general agreement.

TABLE II.—Steam Conditions.

	I	III	II	IV
Boiler pressure in lbs....	141	141	142	140
Corresponding saturation temperature	361	361	361.5	360
Temperature at superheater	800	790	810	790
Steam pressure at engine in lbs.	134	135	139	138
Temperature at engine, before passing reheater...	737	734	761	...
Temperature at engine, after passing reheater	554	590	603	...
Vacuum in inches	27¼	28	28	29
Speed in r.p.m.	140	140	140.5	140

TABLE III.—Relation between Steam Consumption and Electrical Output.

Effective output in kilowatts.	Pounds of steam per hour.	Pounds of steam per electrical unit.
190	2925	15.4
180	2700	15.0
170	2530	14.9
160	2380	14.9
150	2240	14.9
140	2110	15.1
130	2000	15.4
120	1895	15.8
110	1790	16.3
100	1690	16.9
90	1600	17.8

The mechanical power was determined by four Crosby indicators from which cards were taken every quarter of an hour. The consumption of steam was found by measuring the feed-water, which was accomplished by passing it through a pair of carefully gauged tanks. In reckoning the consumption of steam no account is taken of steam used in feeding the boiler, the feed being given by a separate steam feed-pump. The figures include all losses of steam in the boiler and pipes. Some steam was blowing continuously from a joint in the steam-pipe in all the trials, and at times there was a little blow-off at the safety valve. If these losses had been avoided the results as to steam consumption would be even more favorable than they are.

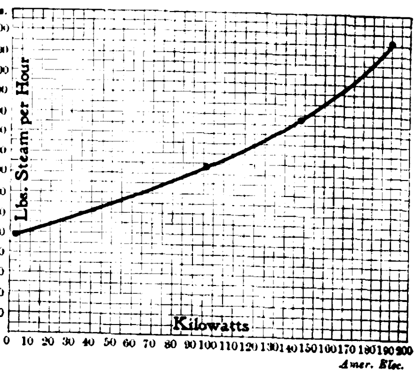


FIG. I.—CURVE OF ELECTRICAL OUTPUT.

A trial under full load lasting seven hours was followed by a trial under half load lasting three hours. On the following day a trial was made under three-quarter load lasting five hours, and this was followed by a shorter run under no load except a few lamps which were used in lighting the engine and boiler rooms. On each day the engine had been running for some hours prior to the tests, so that the temperature had reached a nearly steady state. The results of the four trials have been plotted in curves showing the consumption of steam per hour under all loads. These curves are shown by Figs. 1 and 2, and Table I presents the general results.

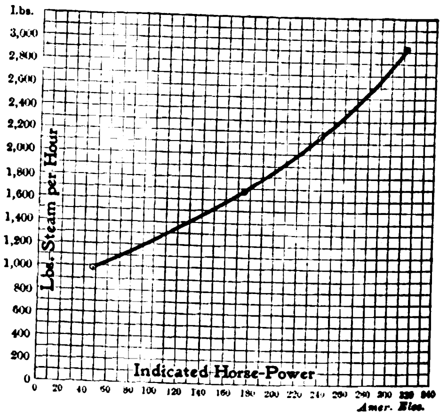


FIG. 2.—CURVE OF STEAM CONSUMPTION.

Table II gives the particulars of the temperature, etc., in the several trials. The steam consumption per hour corresponding to different values of indicated horse-power, and that corresponding to various values of effective electrical output are shown respectively by the curves in Figs. 2 and I. From the form of these curves it will be seen that the best economy of steam occurs when the load is something less than full. Measured from the curve of Fig. 2 the steam consumption at various loads is as stated in Table III.

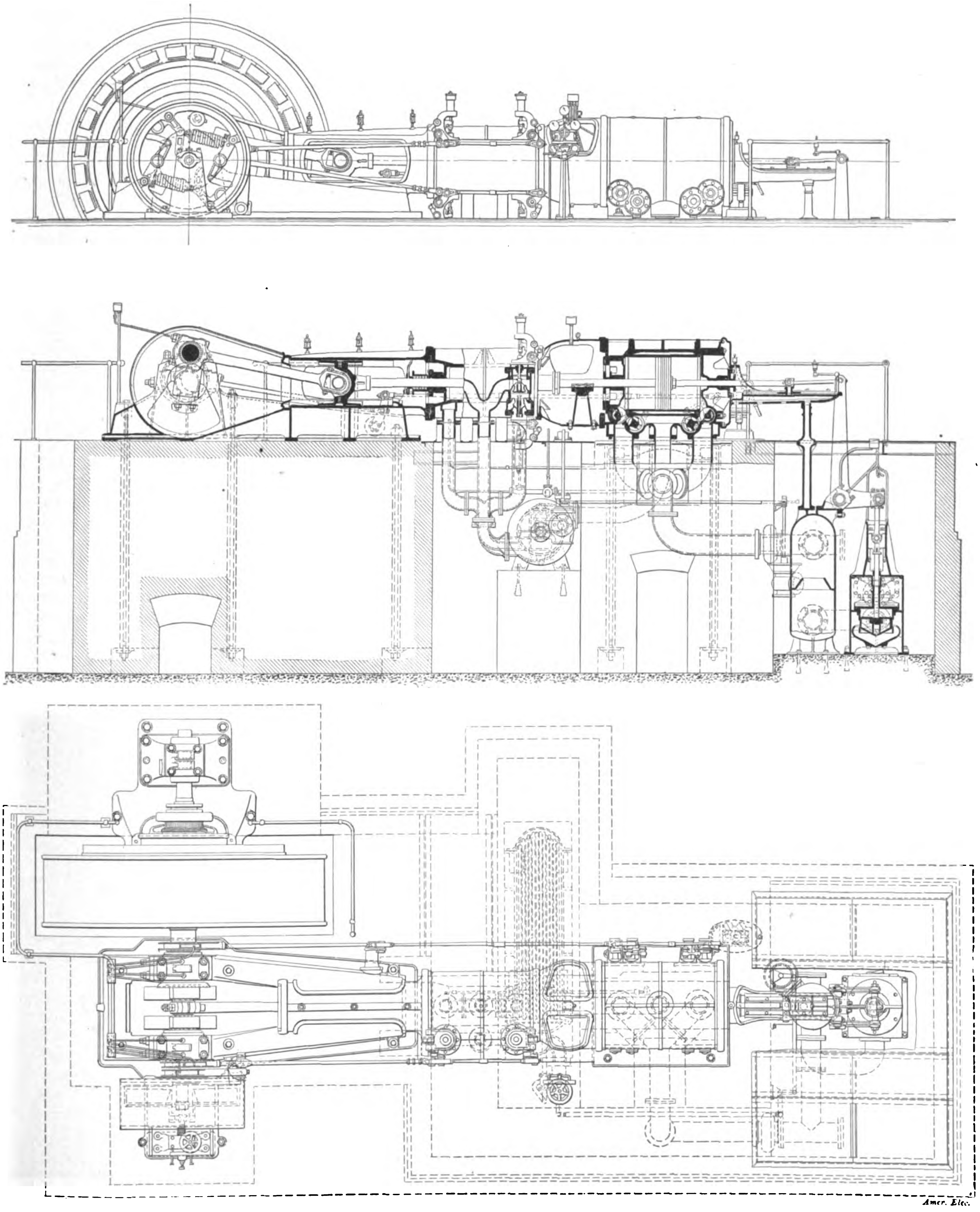


FIG. 3.—SIDE, SECTIONAL AND PLAN VIEWS OF 300-H.P. ENGINE USING SUPERHEATED STEAM.

The trials show that the engine preserves an extraordinarily high efficiency throughout the whole range from full to half load. A consumption of only nine pounds of steam per indicated horse-power-hour, and barely 15 lbs. per electrical unit, is phenomenally small and gives the most striking evidence of the advantage of using high superheat. What makes these results more remarkable is that they were obtained in an engine of only 300 horse-power and having only two cylinders.

In trial No. IV. the generator was fully excited. A further no-load trial was made to determine the power developed when the engine was running at the same speed without excitation; this was found to be 28 indicated horse-power. Allowing for the small lamp-load in trial No. IV, the indicated horse-power required to run without load, but with excitation, was 42. The extra power due to excitation, at no load, consequently corresponds to 14 indicated horse-power.

The weight of coal supplied to the boiler furnaces was determined during the first day, for nine hours, and the weight of coal supplied to the superheater was determined on each of the two days. Both the boiler and the superheater were designed to supply the two engines together, and as only one was running during the trials, they were working at half, or less than half of their intended output. The boiler furnaces have grates adapted for burning small coal with an automatic stoker, but during the trials a larger Derbyshire coal was used, and this was fed in by hand. The superheater was fired with small coal throughout. There was no economizer and consequently the full advantage of the Schmidt system in respect of fuel economy was not to be expected. The results obtained however are very good. The weights of coal burned showed that for each pound of coal put on the boiler grates 8.7 lbs. of steam were evaporated. This is at the pressure of 140 lbs., and from feed-water at 75 degrees Fahr. Also for each pound of small coal fed to the superheater 24 lbs. of steam were superheated to 800 degrees Fahr. Thus the total quantity of coal used in giving heat to one pound of engine steam was

$$\frac{1}{8.7} + \frac{1}{24} = 0.157 \text{ lbs.}$$

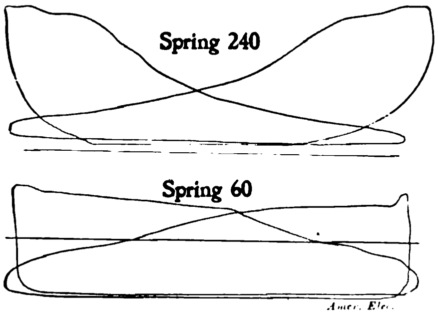


FIG. 4.—FULL-LOAD INDICATOR CARDS.

Taking 9 lbs. of steam per indicated horse-power this makes 1.41 lbs. of coal per indicated horse-power-hour. The calorific value of the coal was subsequently determined in the laboratory at Cambridge, and the tests showed that the coal supplied to the boiler furnaces had a value of 13,300 heat units per pound, while that used in the superheater had 11,900. Having regard to the proportion in which coal was supplied to the boiler and superheater respectively, these figures give 12,970 heat units per pound for the mean calorific power of the fuel as used in the trials. The quantity of coal consumed in making and superheating the steam, namely 1.41 lbs. per indicated horse-power-hour, was accordingly equivalent to 1.22 lbs. of "standard" coal having a calorific value of 15,000 thermal units per pound. Sets of representative indicator diagrams at full load, three-quarter load and half-load are given by Figs. 4, 5 and 6.

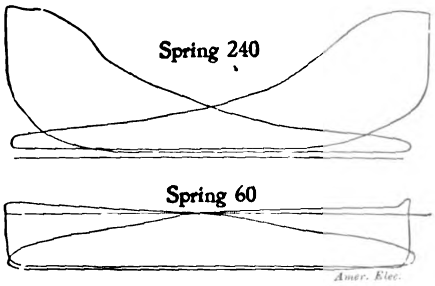


FIG. 5.—THREE-QUARTER LOAD INDICATOR CARDS.

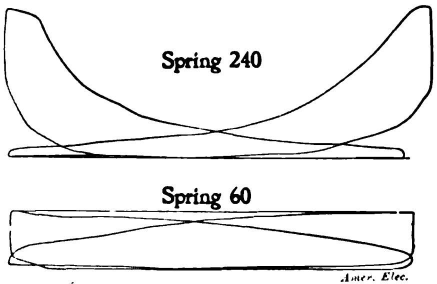


FIG. 6.—HALF-LOAD INDICATOR CARDS.

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AN ELECTRIC CAR LIGHTING SYSTEM.

BY W. L. BLISS.

In presenting this paper, the author assumes that the subject of train lighting from the axle is generally familiar and that no allusion to the previous state of the art, or the many failures and disappointments along this line of engineering is necessary or desirable. The object of the writer is to describe a modern system of train lighting from the axle that is reliable in its operation, and which has passed beyond the experimental to the commercial stage, and is becoming standard railway equipment. This system consists essentially of the following elements:

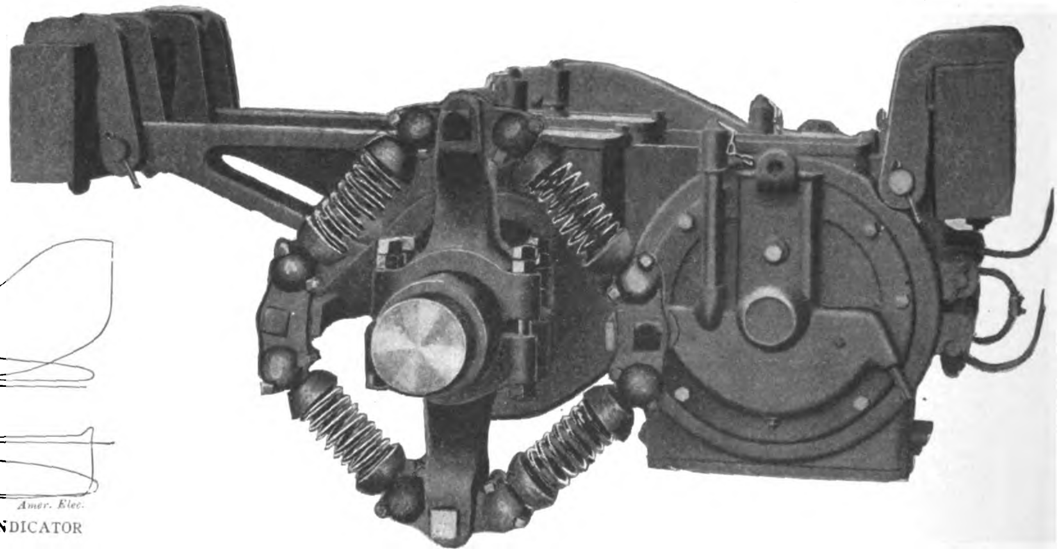
FIG. 1.—METHOD OF DRIVING GENERATOR FROM AXLE.

1.—A dynamo electric machine or generator located on the car, or, as is the common practice in this country, directly on the truck frame, and so arranged that its armature is driven positively from the axle.

2.—Translating devices within the car, consisting in general of incandescent lamps and fan motors, which utilize the electrical energy developed in the generator.

3.—A storage battery carried on the car, the special function of which is to supply the electrical energy necessary to operate the lamps whenever the armature of the generator armature revolves at a speed too low for this purpose, or ceases to rotate, which condition is obviously attained when the car is at rest.

4.—Auxiliary apparatus, which, acting in conjunction with the above, is intended to render the operation of the entire system reliable and automatic.

As the generator in this system is located on the truck frame there must be first provided a machine mounting, and axle connection which shall withstand the injury and abuse coincident with this exposed position. Secondly, there must be provided an axle connection which shall not necessitate any change in the manufacture of standard railway axles. Such axles are rough, tapered and out of true, and no connection which involves the use of keys, set-screws, etc., or which requires turning, trueing or machining the axle in any way will be permitted by railway officials. The reasons for this are obvious and require no further comment.

Fig. 1 illustrates the method adopted for driving the generator from the axle. The generator and driving mechanism are modeled somewhat on the lines of the modern street railway motor, such modifications and additions being introduced as to adapt the apparatus to the special work in hand. A single-reduction, gear-driven generator has been adopted, but, unlike the ordinary street-car motor, the entire weight of the machine is carried on the truck frame, it not being possible to journal on the axle, for the reason previously indicated.

Instead of journaling the axle in bearings attached to the frame of generator, two large brackets are carried out from the frame or casing of the generator and are adapted to receive and support a hollow shaft, which runs on roller bearings, and upon which the split gear which meshes with the armature pinion is mounted. The hollow shaft, as well as the brackets, is divided longitudinally, in order to permit assembling on the car truck. The car axle extends through the hollow shaft, a clearance of nearly two inches all around the axle, and between it and the hollow shaft being provided. (See Fig. 2.)

This clearance permits the axle to take all manner of motions and positions (within certain limits), with reference to the hollow shaft. Only one component of the axle's motion is transmitted to the hollow shaft, this component being that of rotation. All other motions, the horizontal, vertical and end shake, being provided for in a positive though flexible connection between the axle and the hollow shaft. This consists of a two-armed dog clamped on by four bolts securely upon the axle, and four specially constructed driving-springs which are attached by means of ball-and-socket fastenings to the two ends of the dog, and to the two arms of the hollow shaft.

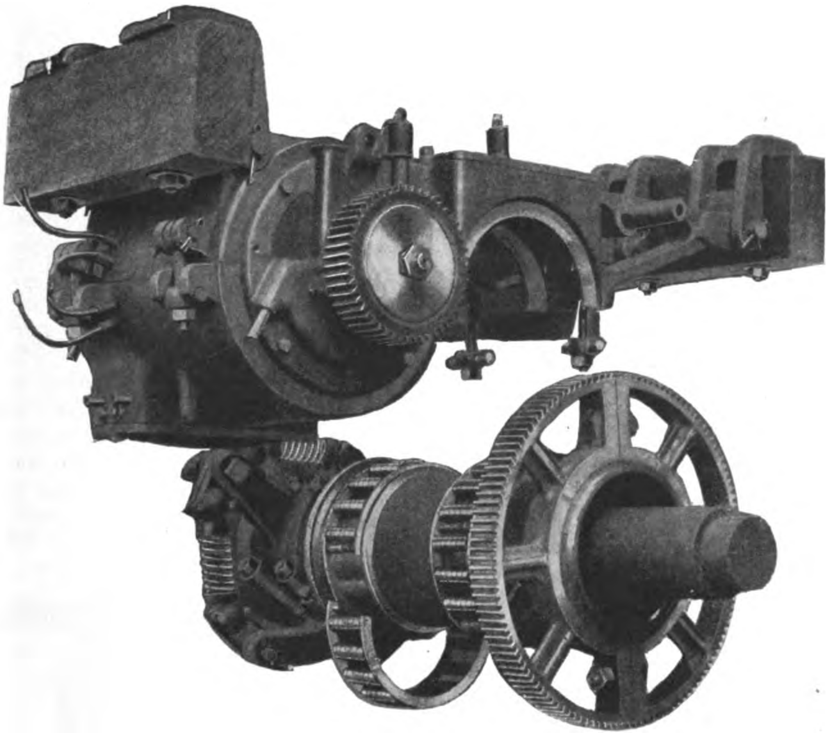

FIG. 2.—METHOD OF ASSEMBLING GENERATOR ON CAR TRUCK.

The driving-springs are helical and wound with tapered ends, and are mounted in shallow cups, through which are screwed ball-ended bolts, which form a part of the ball-and-socket fastening. Inside the springs, the bolts are threaded and provided with nuts and conical washers which fit the inside of the tapered ends of the springs. The nuts are set up with a spanner wrench and locked with spring cotters. An opening is cast in each end of the dog, through the jaws or sides of which a bolt passes, and in this opening and secured by the bolt is a socket-casting split in a vertical plane. The casting projects on each side of the dog and is hollowed out at each end like a bullet mould, thus forming two spherical sockets, into which the ball-ended bolts of the driving-springs fit. The two halves of this socket-casting are bolted together to prevent their springing open and allowing the balls to wear on the joint between them. Similar socket-castings are secured to the two arms or cranks of the hollow shaft by means of bolts or studs which act as crank-pins. All these castings and fittings are interchangeable.

The springs are, initially, neither in compression nor extension, which feature greatly facilitates assembling. In operation, two diametrically opposite springs are in compression, while the other pair are in tension, and *vice versa*, depending on the direction of rotation of the axle and hollow shaft. The dog need not run true, and no special care need be exercised in mounting it on the axle, it being quite as effective when not so true as when nicely adjusted.

There is a positive advantage in not carrying any of the weight of the generator on the car axle. Supported as the generator is, entirely on the truck frame, it is free from the shock, vibration and pounding which would be communicated to it were it journaled on the axle, as in a street railway motor. It is very easy with this construction to put the generator out of operation by simply taking the dog off the axle. But the greatest advantage which results from this construction is the absence of necessity for trueing up anything in installing the machine. An approximate centering of the axle in the hollow shaft, and the coarsest kind of work in mounting the dog on the axle, are all that are necessary. All the trueing and lining up are done in the shop, and no knowledge of machine work is required of those who install the machine.

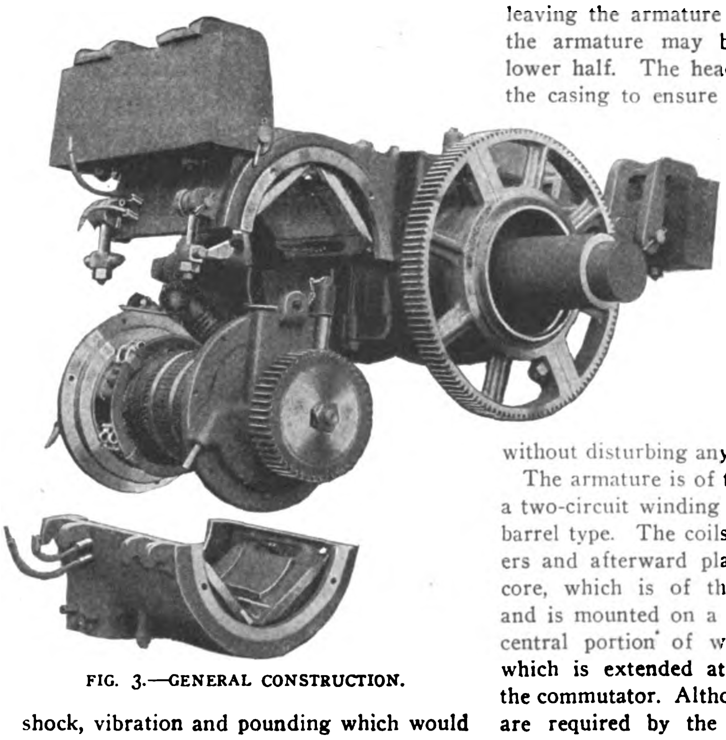

FIG. 3.—GENERAL CONSTRUCTION.

All parts of the mechanism which require it are thoroughly encased or otherwise protected. Automatic and profuse lubrication of the shaft bearings is provided. A cut steel gear on the hollow shaft drives a fibre pinion on the armature shaft. In consequence these are run dry without lubrication of any kind, which conduces much to the cleanliness of the apparatus.

The generator is of the ironclad type, having four internal radial poles, two in the upper and two in the lower half of the generator, which is divided longitudinally in a horizontal plane. The casing which forms the yoke of the field magnet is extended parallel with the axis of the shaft and is then turned in at right angles, as shown in Fig. 3, which illustrates the general construction. The ends of the casing are bored out and have fitted into them round head-like castings which hold the armature-shaft bearings and oil-wells. When the heads are in place the generator is almost hermetically sealed, and is absolutely dust and water-proof. Suitable hand-holes or doors are provided in the generator casing for purposes of inspection, etc. The two heads which carry the armature bearings are each held in place by four bolts, two of which are tapped into the upper half of the generator casing and two into the lower. Consequently, the lower half of the generator may be removed, leaving the armature in the upper half, or the armature may be removed with the lower half. The heads are nicely fitted to the casing to ensure the perfect alignment of the armature shaft, no steady pins or other trueing devices being used. By removing the head-casting at the commutator end and detaching the flexible cables from their respective brush-holders, the entire brush mechanism may be removed without disturbing any of the working parts.

The armature is of the drum type, having a two-circuit winding of the straight-out or barrel type. The coils are wound on formers and afterward placed on the armature core, which is of the usual slotted type and is mounted on a ventilated spider, the central portion of which forms a sleeve which is extended at one end to support the commutator. Although only two brushes are required by the two-circuit winding, four are used in order to reduce the axial dimension of the commutator, and also to obtain sufficient friction between the commutator and the brushes to rotate the brush "rocker" or carrier, as described in the next paragraph.

Provision must be made for the fact, that the direction of travel of the car will be reversed, and hence the direction of rotation of the armature of the generator will suffer a reversal. This would render a self-excited generator inoperative, or would cause a reversal in the polarity of the brushes or terminals of a separately excited machine. In this system, the polarity of the terminals is preserved in the following manner: The brush-holders are mounted on a carrier, which is supported on anti-friction bearings, which enable it to rotate freely within the casing of the generator. The friction between the brushes and the commutator is sufficient to cause the former, and with them the carrier, to be dragged around as the commutator revolves. The rotary motion of the carrier is arrested by means of a stop. When the armature revolves in a right-hand direction, the brushes and carrier are rotated to the right and arrested by the stop in the correct position for commutation. When the armature revolves in a left-hand direction, the brushes and carrier are rotated to the left through practically 90° into the position correct for commutation in that direction, but a position such that the polarity of the brushes would have been reversed, had not a reversal of rotation in the armature taken place simultaneously. The stop which arrests the motion of the carrier is removable, in order that the carrier may be turned completely around and all the brushes and holders brought opposite the hand-holes in the generator casing for inspection purposes and the renewal of brushes.

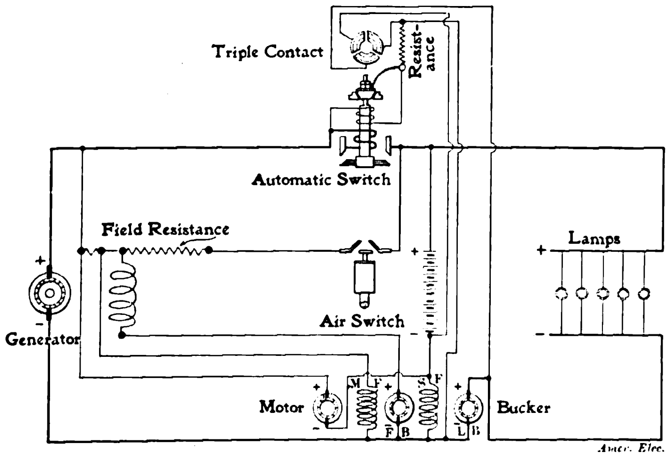

FIG. 4.—DIAGRAM OF CONNECTIONS.

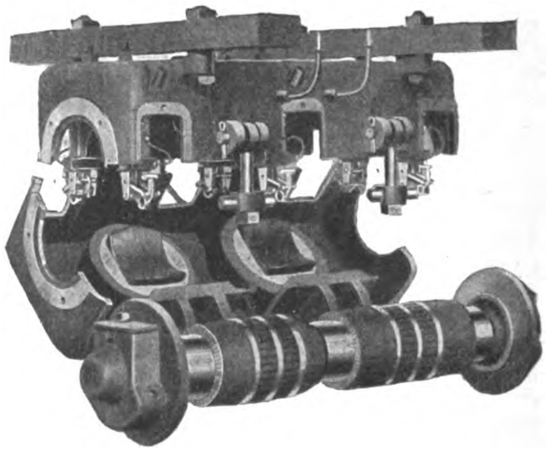

FIG. 5.—BUCKER WITH ARMATURES, REMOVED.

The automatic auxiliaries also include a switch to complete the circuit between the generator and the storage battery whenever the speed of the former, and consequently its e.m.f., is equal to or greater than that of the battery; this switch also breaks the circuit whenever the voltage of the generator is less than that of the storage battery. The automatic switch opens and closes the circuit between the generator and the storage battery electrically, and is controlled directly by the generator voltage. It consists of a rectangular iron frame, which forms the magnetic circuit of a solenoid and supports insulated contacts. Within the frame are two concentric coils, constituting the solenoid. They are made entirely separate in order to facilitate construction and repairs, and are held in place by a central tube. The inside, or lifting coil, is wound with fine wire, and is connected to the terminals of the generator. The outside, or releasing coil, is wound with heavy wire and connected in series with the generator and storage battery. Within the central tube, and free to work in a vertical direction, is a soft-iron plunger, attached to and insulated from which is a laminated metal brush. When the generator develops its normal e.m.f. of 64 volts, the fine wire or lifting coil will raise the plunger, thus causing the metal brush to close the circuit. If the generator voltage is increased, current will flow from it through the series coil and the battery, the series coil being connected in so that this current aids the shunt coil in holding up the plunger and brush, maintaining a better contact for increasing current. When, however, the voltage of the generator becomes less than that of the battery, current will flow from the battery in a reverse direction through the series coil and generator and oppose the action of the shunt coil, allowing the plunger and brush to drop and thus open the switch. No springs are used to secure the adjustment. Adjustment is made by varying the length of the air-gap, and when once made it is permanent. Carbon contacts, on which the final break takes place, protect the metallic parts against injury by arcing. Fig. 4 is a diagram of the connections of the system.

Upon the top of the iron frame of the automatic switch is mounted a triple contact, consisting of a three-part segmental socket and a conical plug fitting the same. The plug is raised and lowered by means of a tail-rod attached to the plunger of the switch. When the plunger is down and the generator switch open, the plug connects the three segments together. When the plunger and plug are raised by the lifting coil, the triple contact is broken. The plug is insulated from the tail-rod and a flexible conductor permanently connects the plug with an insulated terminal, also mounted on the iron frame. One lead of a resistance coil, located in the upper part of the switch-box, is connected to this insulated terminal, and the other lead is connected to the front segment of the triple contact. The negative lead of the generator is also connected to this segment. The leads of the lifting coil are connected, respectively, to the positive of the generator and the terminal to which the flexible conductor is attached. Thus it will be seen that when the plug establishes the triple contact, it also short-circuits the resistance coil. When the plug is raised, it throws the resistance into series with the lifting coil. The objects of this are to reduce the current and consequent heating in the coil, which would otherwise change its resistance and alter the adjustment of the switch, and to reduce the magnetizing effect of the coil, so that less discharge current will be required in the releasing coil to open the switch.

The function of the triple contact is to short-circuit the lamp circuit "bucker" and series field, to be described later, thus avoiding the drop that would otherwise take place in the lamp circuit when the battery was discharging, and to render the "bucker" inoperative at train speeds below 20 miles an hour, when the generator switch is open.

It is desirable to have the generator develop its normal voltage, equal to that of the battery, at as low a speed as possible, consistent with economic design, in order that the electrical energy developed by the generator may be available during as long a proportion of the car's travel as possible. In this system the generator is so designed and so geared to the axle that with a train speed of about 20 miles an hour it is driven at 500 r.p.m. and generates 64 volts. The voltage delivered to the battery rises to 80 volts at maximum speed, or approximately 2.5 volts per cell, which is ample to force the full charging current through the battery, while the voltage at the lamps is kept constant by the "bucker." This lamp voltage may be 60 to 65 volts, but whatever the figure chosen, it is maintained practically constant regardless of the train speed or the number of lamps in circuit.

The "bucker," referred to above, is a separate self-contained motor-generator, and is bolted to the bottom of the car in any convenient place. The machine contains two armature cores on a common shaft, and two field magnets with a common yoke structure, as clearly indicated in Fig. 5. One of the armatures, with its commutator and field, constitutes a plain shunt motor which takes its power from the generator mains and the sole function of which is to rotate the shaft. It is obvious that this motor runs only when the generator is in operation. The other armature has two windings and two commutators, and revolves in a field excited by the current flowing through the battery (indicated by *S F*, Fig. 4). This double-wound armature, with its two commutators and field, constitutes the "bucker" proper. The armature connected in the lamp circuit is called the "lamp bucker," and the winding connected in the field circuit of the generator the "field bucker." The field winding of the "bucker" is referred to as the series field, that of the motor as the motor field.

Fig. 5 represents the complete "bucker," with the armatures removed and the field magnet structure open, to show the internal construction. The brush-holders are mounted rigidly in the upper half of the machine, and their springs, fingers and cams are interchangeable with those of the generator. The head-castings, containing the armature-shaft bearings, may be left bolted to either half of the casing when the latter is opened.

When no current flows through the battery, none flows through the series field, and hence no e.m.f. is generated in the "bucker"; but when current flows through this series field the two bucker armature windings generate e.m.fs. that are in almost exact proportion to the strength of the field. After the closing of the automatic switch, the motor runs at almost constant speed; the slight acceleration as the generator voltage rises from 64 to 80 volts is an advantage, as it compensates for the drooping curve of magnetization in the series field.

No current will flow through the series field under the following conditions: (1) When the generator is inoperative, the automatic switch is open, and no lamps lighted; which conditions are obtained when the car is standing still in day-time. (2) When the generator is operative, the automatic switch closed, no lamps lighted and the generator voltage is equal to the battery voltage; this occurs when running 20 miles an hour in day-time. (3) When the generator is operative, automatic switch closed, lamps lighted and batteries carrying all or a portion of the lamp load, *e. g.*, running 20 miles an hour at night; current would, in this case, flow backward through the series field if it were not prevented from so doing. (4) When the generator is operative, automatic switch closed, lamps lighted, and generator just carrying the lamp load, batteries neither charging nor discharging, *e. g.*, when running 25 miles an hour at night.

Under these conditions, no regulation of the generator or the lamp circuit is necessary. The only condition requiring regulation is when the generator speed and voltage have risen and the battery is being charged, that is, when the train is running above 25 miles an hour, day or night.

The voltage at the terminals of battery rises about in proportion to the current forced through them, and the magnetism of the series field increases in proportion to this current. The e.m.fs. of the "bucker" (its speed being nearly constant) increase in proportion to its field magnetism. Hence, the e.m.fs. of the "bucker" increase in proportion to the rise of e.m.f. at the battery terminals, and the armature winding connected in the lamp circuit is proportioned so that its e.m.f. is practically equal at all times to the increase of e.m.f. at the battery; and as this winding is connected inversely in series with the lamps, it produces a counter e.m.f. in the lamp circuit always equal to the excess e.m.f. necessary to impress on the batteries to charge them.

The other armature winding of the "bucker" is connected in series with the field of the generator, in opposition to the e.m.f. of that circuit, and its e.m.f. weakens the field to such a degree that the e.m.f. of the generator is just sufficient at the maximum train speed to force the maximum predetermined current through the battery and the series field. The regulation tends to maintain constant current through the battery and series field at a given train speed. The lamp load is carried by the generator precisely as in the case of a constant potential machine and does not affect the charging current flowing through the battery.

Since the "bucker" receives energy from the lamp circuit and the field circuit of the generator, such energy is transformed into mechanical power and tends to revolve the shaft and thus relieve the motor of that work. In fact, when the apparatus is fully loaded, the motor becomes a generator and puts back into the system about 60 per cent of the energy consumed by the "bucker" in effecting regulation.

Under condition (3), stated above, no regulation for holding down the lamp voltage or the generator output is necessary, but since, under such conditions, the battery would discharge and current would flow from the battery through the lamps, "lamp bucker," and backward through the series field, the polarity of the "bucker" would be reversed, and the latter would become a booster and tend to raise the lamp voltage and increase the generator output by strengthening the field of same. This tendency of the "bucker" to "boost" when the battery discharges through the series-field winding while the generator switch is closed and the triple contact open is prevented by causing the current which flows from the generator through the motor to return through the series field in a direction opposite to that of the battery current discharging through the lamps and series field. (See Fig. 4.) This motor current increases with the tendency of the "bucker" to "boost,' which tendency is proportional to the lamp load at this time, for the more heavily the "bucker" (now a booster) is loaded the greater the motor current required to drive it. The resultant of these two currents, which in this case is their difference, is approximately zero; or, at least, the tendency to "boost" is practically eliminated.

In this system, the generator operates normally as a self-exciting machine, but in order to insure quick "picking up," separate excitation for the field of the generator, and also for the field of the motor which drives the "bucker," is supplied by means of current from the storage battery, which current is limited to a small value by the field resistance, and is used only at starting. The circuit from the storage battery through the field resistance is controlled by the air switch, shown in Fig. 4. This consists of a cylinder, to the lower end of which a branch from the signal pipe of the car is connected. An ordinary gas-cock, included in this branch pipe, serves to cut off the supply of air, so that the cylinder may be opened or disconnected without venting the signal line.

Within the cylinder is a cup-shaped piston, to which a rod is attached. The latter extends through the cylinder head and carries an insulated contact disk. The piston is held in its normal position by means of a helical spring surrounding the piston rod and engaging with the inside of the cup-shaped piston and the under side of the cylinder head. When the piston is forced upward by air pressure, the rim of the cup is pressed against the gasket which packs the cylinder head, thus sealing the cylinder and preventing escape of air. At the same time the contact disk on the piston-rod establishes connection between the two insulated spring contacts mounted on the cylinder head, closing the circuit for separate excitation.

When the locomotive is coupled to the train and the hose couplings are connected, pressure is at once applied to the air-switch and the generator field circuit is closed. When the locomotive is uncoupled, the pressure in the signal pipe rapidly falls, opening the air-switch immediately, or within a few minutes. Reduction of pressure caused by giving signals does not open the switch, and even if it did, no harm would result, as the switch may be opened with impunity as soon as the generator has developed a stable e.m.f. of about 15 volts. When the automatic switch closes, it short-circuits the air-switch, in addition to its other functions. After the disconnection of the locomotive, the conductor's valve may be used to open all the switches on a train simultaneously, in case the pressure in the signal pipe is retained. The leaks in the hose couplings are sufficient to cause a rapid falling in pressure and a quick opening of the air-switch.

[The foregoing is an abstract of a paper read at a recent meeting of the American Institute of Electrical Engineers.]

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A New Timber-Treating Process. — Interest has been aroused in England over a new method of treating timber. The process consists in the injection of a solution of sugar at the boiling point, the water being afterwards evaporated at a high temperature. The result is to leave the pores and interstices of the wood filled with solid matter. The nature of moderately soft wood, it is claimed, is in this way changed to a tough and hard substance, without brittleness, and also without any tendency to split or crack. It is rendered remarkably impervious to water. Hard woods similarly treated derive similar benefits.

Abstracts from Foreign Contemporaries

Arc Lamps With Impregnated Carbons.—J. Zeidler contributes a long illustrated article to a recent number of the *Elektrotechnische Zeitschrift* in which he describes the various arc lamps made by the Allgemeine Elektricitäts-Gesellschaft and using impregnated carbons. Unlike the carbons used in the Bremer arc lamp, these carbons contain additions of salts only in the core and in such quantities and of such quality as to become entirely gaseous in the arc so that no insulating slag accumulates on the ends of the carbons, which might influence the light and the proper working of the lamp. There are two types of lamp in use, one in which the two carbons are vertical, one above the other, as usual; the other in which the carbons are inclined with the arc at the bottom. The former are called "flame arc lamps" and the latter are termed "intense flame arc lamps" (intensivflammenbogenlampen). The lamps, which are of a modified differential type, are made for both direct and alternating current, the double form of each type being shown by Figs. 1 and 2 respectively. The lamps do not differ materially in construction from the ordinary arc lamps of the company, the differences which do exist being due to the fact that in order to obtain a quiet, steady light it is necessary that the ends of the carbons should have a comparatively small surface. For this reason the carbons used are thin, the same diameter of carbon being used for both the positive and the negative. On the other hand the impregnated carbons are consumed much more quickly so that in order to get a practical life for the lamp it is necessary to use long carbons. These are used in lengths of from 13 to 20 inches. In order to obtain a still greater life, lamps are made with two pairs of carbons, as shown by Figs. 1 and 2, in which when one pair is consumed the other is automatically lighted. The lamps contain two mechanically independent differential mechanisms, which are connected electrically; the two main windings being in series with the one or the other pair of carbons; the shunt windings are in parallel with the arc. All of the coils are therefore always supplied with current, although only one arc is lighted, and while this necessitates a small waste of energy it gives a greater surety of working. On 110-volt circuits there are two direct-current or three alternating-current lamps in series; on a 220-volt direct-current network there are four or five in series, while on an alternating-current network of the same potential there are six flame arc lamps or four or five intense flame arc lamps in series. The hemispherical intensity of the direct-current intense flame arc lamp, taking 9 amperes at 220 volts, is about two or three times that of the ordinary direct-current arc lamp, while for alternating-current it is about four times as much. Fig. 3 shows a diagram giving the illumination of a surface by different lamps. The zero point of the axis of abscissas represents the point of the surface perpendicularly below the lamp, while the abscissas represent the distances in meters from this point; the ordinates give the illumination in *luces*. *A* is for a 45-volt, 10-ampere, direct-current intense flame arc lamp; *B* for a 45-volt, 10-ampere, alternating-current intense flame arc lamp; *C* for a 45-volt, 10-ampere, direct-current flame arc lamp; *D* for a 30-volt, 10-ampere, alternating-current flame arc lamp; *E* for a 40-volt, 10 ampere, arc lamp with non-impregnated carbons, and *F* for a 30-volt, 10-ampere arc lamp with non-impregnated carbons.

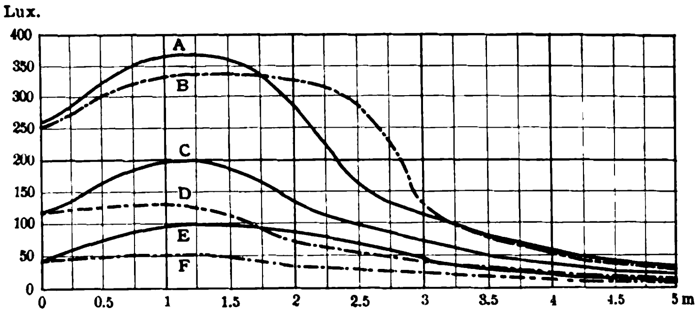
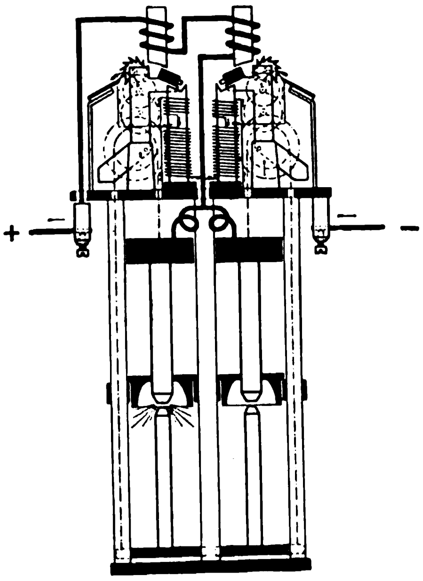


FIG. 3.—ILLUMINATION CURVES.



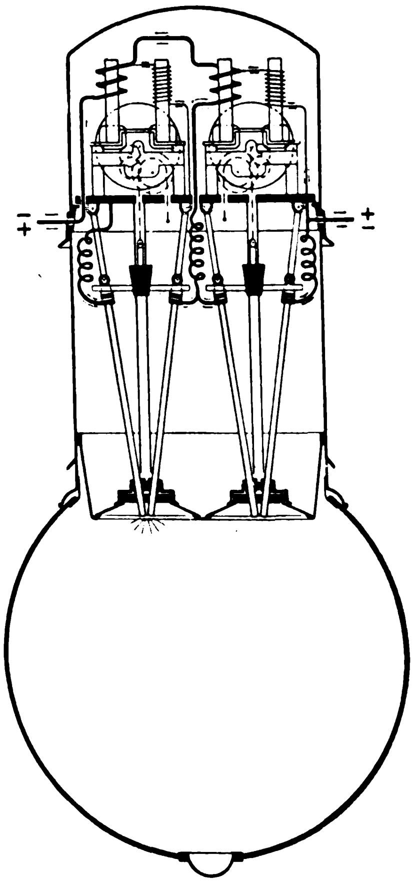


FIG. 1.—DOUBLE-ARC LAMPS WITH IMPREGNATED CARBONS.—FIG. 2.

Improved Jointing Arrangement for Tubular Surface Condensers.—A neat and effective arrangement for allowing for the expansion or contraction of the tubes in surface condensers, coolers, etc., has been designed by William Shore, and forms the subject of a recent article in the London *Mechanical Engineer*. The arrangement consists essentially of a chamber containing the tubes, closed at each end by a tube plate, into which the tubes are expanded. One of these plates is rigidly connected to one end of the chamber, whilst the other is free to move in accordance with the expansion or contraction of the tubes. In order to make a good joint between the free tube plate and the chamber, a flexible packing is inserted, which is forced by the pressure in the headers and the pressure due to the longitudinal expansion of the tubes into a suitable groove formed between the tube plate and the header. The chamber is provided with suitable branches for the inlet and outlet of steam or other fluid, the headers at each end being provided with similar branches. Referring to the accompanying illustration, *A* A_1 are the inlet and outlet branches to and from the tube chamber *B*, and *C* the inlet and outlet branches to and from the headers *D* D_1. The tubes are rigidly attached to the plates *E* and *F*, the plate *F* being made so that it is free to move longitudinally, and in order to make a joint be-

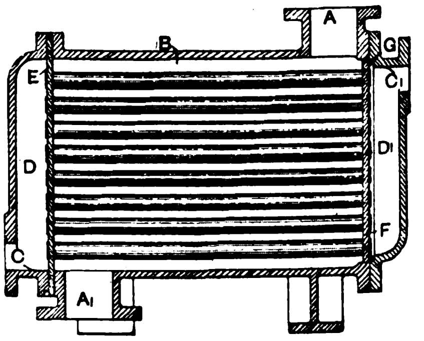


FIG. 4.—JOINTING ARRANGEMENT FOR CONDENSERS.

tween the plate *F* and the header D_1, the edge of the plate is bevelled or recessed, and a similar recess is formed in the face of the header. Between the surfaces thus formed a flexible ring of packing material *G* is inserted, so that when the tubes expand a tight joint is formed.

Richmond's Surface Condenser.—In the case of surface condensers taking their supply of circulating water from rivers, ponds or the like, considerable difficulty is frequently experienced owing to mud, leaves or other foreign substances being drawn into the supply passages, and partially if not entirely choking the same. Fig. 5, taken from the London *Mechanical Engineer*, shows an arrangement of surface condenser, designed by John Richmond, of Glasgow, which has for its object to prevent such permanent choking action. This is accomplished by providing two circulating pumps capable of independent action in reverse direction through the condenser and discharging through one another or by separate passages, or by otherwise reversing the direction of flow as may be required, say, for example, by a single pump and an arrangement of pipes and valves so that the condenser flow may be reversed as desired. The condenser consists of a vertical cylinder having a chamber *I* at its upper end and a chamber at the base, the latter being divided into two compartments, *D* and *E*, each again partially divided by vertical diaphragms *M M*. Communication is obtained between the compartments *D E* and chamber *I* by means of two series of condensing tubes arranged in a chamber *P*. At or near the base of the condenser are arranged two circulating pumps *1* and *2*, capable of independent action and each having communication with one of the compartments *D* or *E* of the lower chamber by connections *B C* respectively with the flanged mouths *N N*. The steam enters the condensers by means of a pipe *C* which passes through the chamber *I* and extends down some way into the interior of the chamber *P* and carries a baffle plate *L* at its inner end, a second baffle plate *K* being secured to the wall of chamber *P* at a suitable distance above the plate *L* to compel the steam to take a course as indicated by the arrows. The water of condensation passes out by a suitable outlet in the central passage *C*. The operation of the apparatus is as follows: The circulating or cooling water, drawn from any suitable supply, by, say, the pump *2*, is forced through the pipe *C* into the compartment *E* of the lower chamber, the partition *M* equalizing the rush of water over the chamber. The water then rises through the series of tubes *G G* above the compartment *E* into the chamber *I*, from where it passes down the second series of tubes parallel to the series *G G* into the compartment *E*, and so through the pipe *B* and pump *1*, the latter assisting the movement of the liquid through the condenser so that an efficient circulation is attained. If now the action of the pumps is reversed the flow will be reversed, and the passages, tubes, and other parts will have the rubbish and like foreign matter collected on or in them removed.

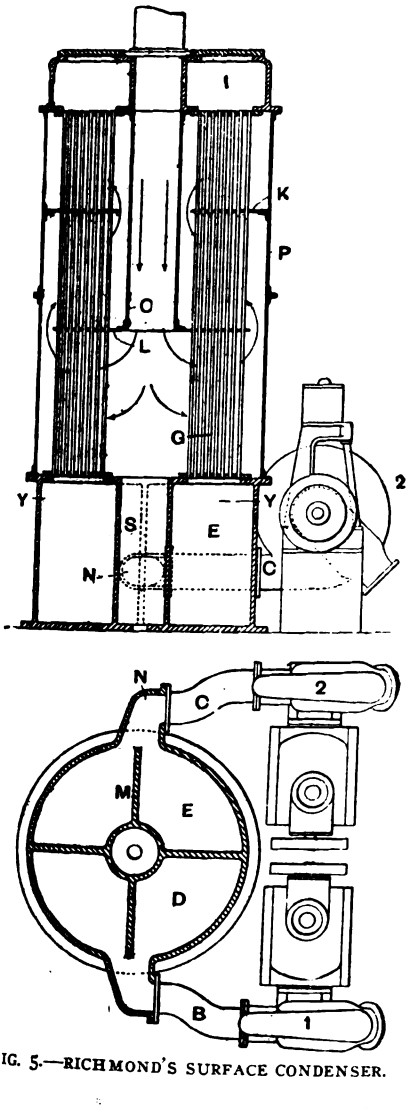


FIG. 5.—RICHMOND'S SURFACE CONDENSER.

New Peard Fuse.—Fig. 6 herewith, taken from the London *Electrician*, shows a form of non-explosive and silent high-potential fuse, which should prove of service to central stations. In this form of the Peard fuse the unpleasant characteristics which result from the explosive properties of the ordinary types of fuse are eliminated, and in their place is an underground cut-out contained within a small hermetically-closed metal case. The arc which momentarily exists on the disruption of the circuit is confined to and extinguished inside the fuseholder. The device, as shown, is exceedingly simple in construction; it consists of a small and strong metal case, *A*, filled in with plaster of paris, and having the necessary vertical and transverse channels in the form of a cross. The fuse, *G*, which traverses the cross-channel, is reduced where it passes over the movable shutter, *F*, which is pressed against it by compressed helical springs, *H;* when the fuse melts the screen is propelled forward and cuts the fuse in two parts, and, by dividing the chamber effectually prevents the continuance of an arc. The small quantity of the fuse thus melted and volatilized is immediately condensed and absorbed by the plaster forming the body of the fuseholder. The large cooling surface offered by the metal containing case is amply sufficient to radiate the small amount of heat generated by the fuse, and it has been found practicable to run the fuse at a dull red heat continuously without in the least damaging the utility of the device. This form of the fuse has been submitted to exhaustive trials on overloads and short-circuits, and has given satisfactory results.

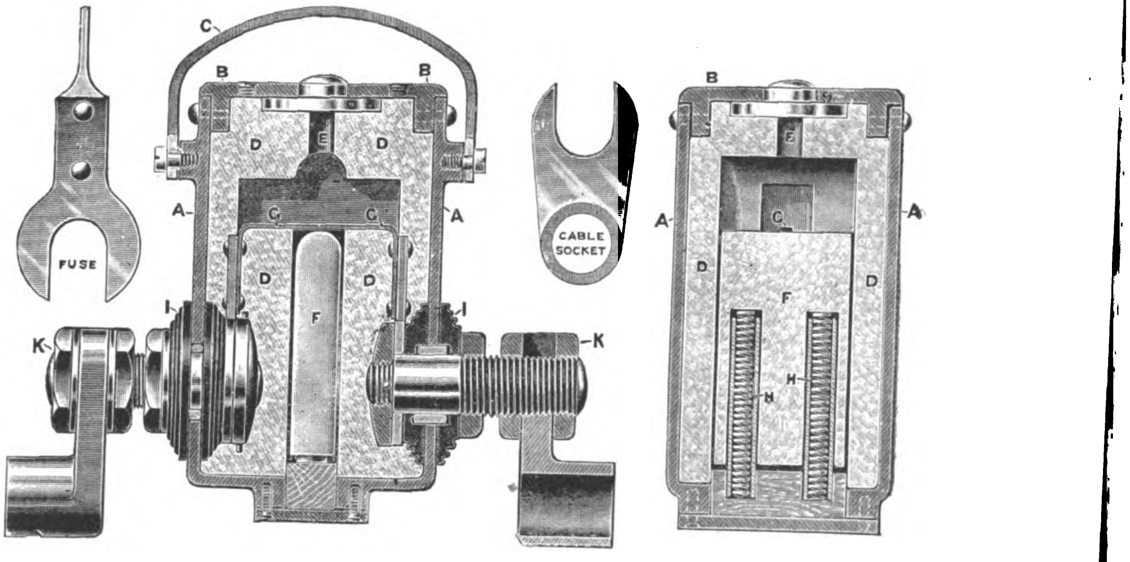


FIG. 6.—SIDE AND END SECTIONS OF PEARD FUSE.

Improvements in Surface Condensers.—Several improvements in and relating to surface condensers have recently been made by S. E. Alley and A. Robertson, of Glasgow, and described in the *Mechanical Engineer*, by means of which the water of condensation is discharged from the condenser by natural gravity, and the vacuum within maintained at its highest efficiency, and the necessity of using an expensive air pump is obviated. The improvements comprise a discharge pipe which is fitted to the condenser, of a length to allow of a vertical fall sufficient to overcome the atmospheric pressure, and which may be 33½ feet or more. The end of the discharge pipe is led into a water seal from which the water of condensation is pumped as it rises above the level necessary to form a seal against the atmospheric pressure. The pumping apparatus may be continuous in action or may be set in motion by a float or other device arranged in such a manner as to regulate the speed of the apparatus and maintain the necessary level of water seal to prevent escape of air into the condenser, or in some cases it may be allowed to escape by an overflow pipe fitted at the required level, or in other cases the lowering of the level of the water in the tank may uncover the inlet of the pump and so prevent further discharge. Any incondensable vapor or gases will be drawn off from the top of the condenser by a small air pump or by a steam, air or water ejector or other similar apparatus.

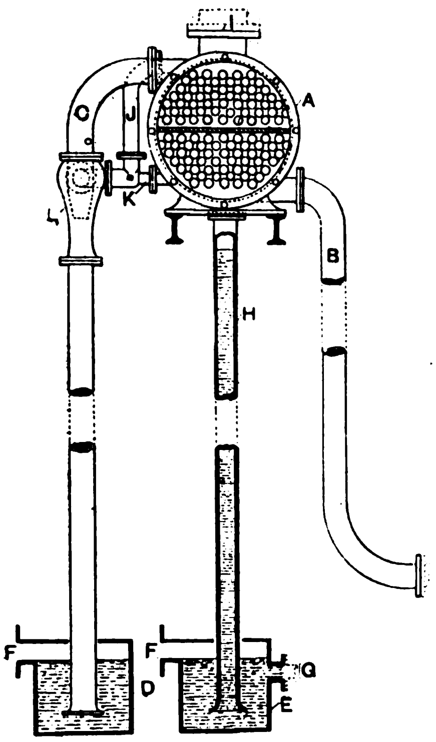


FIG. 7.—ALLEY AND ROBERTSON'S IMPROVEMENTS IN SURFACE CONDENSERS.

One method of carrying the improvements into practice is shown in Fig. 7. The condenser, *A*, which is supported at the necessary height, receives the exhaust steam by the inlet *I* connected to the exhaust pipe of the engine, and is supplied with the cooling water through the pipe *B* leading from any suitable pump or supply of gravitation water. The cooling water, after passing through the condenser, is discharged by the pipe *C* into the tank *D*, provided with an overflow outlet *F*, situated at a distance below sufficient to overcome the atmospheric pressure and prevent the return of air to the interior of the condenser through the pipes *J* and *K*. The water of condensation flows down the pipe *H* by natural gravity, and is discharged into a tank or hot well, *E*, provided with an overflow outlet, *F*, and a branch, *G*, through which the water is pumped to supply the boiler. Any incondensable vapors and air in the condenser are drawn off through the pipes *J* and *K* and discharged into the pipe *C* around the nozzle *L*, the suction being produced by the lateral action of the water falling through the nozzle.

The Manufacture of Incandescent Lamps.—In a recent issue of *Le Génie Civil*, M. Paul Razous gives a short description of the present methods of making incandescent electric lamps in France. The carbon filament for a 10-candle 110-volt lamp is, he states, 1-20 millimeter (1-508 in.) in diameter. A glass foundation is first prepared to receive the filament, this foundation being distinct from the bulb proper, and to it are secured the copper contact-pieces which enable the lamp to be readily placed in circuit. The filament itself is not connected to these contact-pieces direct, but by two wires, each of which is made in three pieces, welded together end to end in the blow-pipe. The middle portion of these wires is of platinum, which, for the sake of economy, is only of sufficient length to reach through the glass foundation. Inside the bulb nickel wires are used connecting the platinum wires to the filament, and outside of the bulb copper wires connect the platinum to the contact-pieces. The filaments themselves have to be very thin and uniform, and are prepared from cellulose. This cellulose is dissolved in zinc chloride to form a viscous sirupy liquid, which is squirted through a fine orifice into a bath of methyl-alcohol. The threads thus obtained have much the appearance of horsehair. The filaments are secured to the nickel wires by fixing them in position and then plunging the whole in a bath of petroleum. On passing a current through the filament and its mounts, the points of junction, being those of least conductivity, become very hot. The petroleum is broken up by the heat, and carbon in a very dense state is deposited on the joints. The filament is next "flashed," being covered in this operation with a layer of dense carbon, which makes good any local lack of uniformity, and provides the whole filament with an outer layer having a high emissivity. This flashing is accomplished by connecting the filament to suitable terminals and covering it with a bell-jar. An air-pump enables the jar to be exhausted, while gasoline vapor can be admitted through a valve. A current is then passed through the filament, causing it to glow. Carbon is thereupon deposited from the gasoline vapor, diminishing the resistance of the filament. When this resistance reaches the standard for the type of lamp being made the current is cut off automatically and the filament is then ready to be fixed in its bulb. This is done by fusing together the glass mount, carrying the filament, and the bulb, which has already been blown to receive it. The bulb is next exhausted, the first stages being accomplished by means of an ordinary air-pump, and the remainder of the air extracted by a mercury pump. The Sprengel type of pump is that used in France.

SOME RECENT ELECTRICAL PATENTS

Regulator for Steam Engine-Driven Dynamos.—It is well known that in steam engines the pressure at certain points of the steam cycle varies approximately in proportion to the work being done, as for example, the steam pressure in the intermediate and low-pressure receivers of a triple-expansion engine. As the output increases, the steam pressure at these points rises, attaining its maximum when the engine is working at full load, and *vice versa*. C. E. L. Brown, the well-known Swiss engineer, has devised and patented a system of dynamo regulation based upon the foregoing fact, which system is illustrated diagrammatically by Fig. 1 herewith. Judging from the illustration, the regulating system was devised chiefly for use in connection with the steam turbine, the prime mover shown in the illustration being of this type. The regulator consists of a rheostat, *7*, connected in series with the shunt field winding of a direct-current dynamo, the arm of this rheostat being geared to the rod of a piston working in a small cylinder, *3*. A helical spring normally holds the piston and rheostat arm in the position which gives the dynamo minimum field strength. The cylinder, *3*, is connected by a pipe to a part of the turbine casing in which the steam pressure varies approximately according to the work being done by the turbine. Consequently, as the load increases the steam

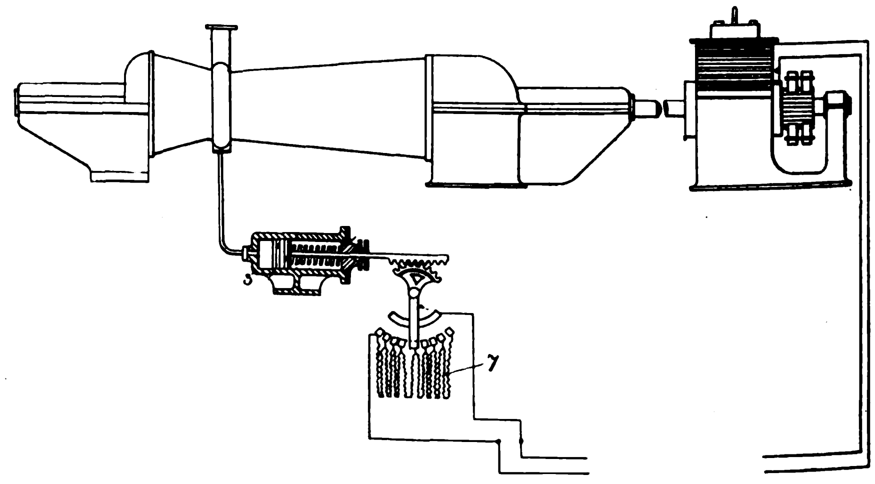


FIG. 1.—REGULATOR FOR STEAM ENGINE-DRIVEN GENERATORS.

pressure increases and forces the piston outward until equilibrium between the helical spring and the steam pressure is attained. This action obviously strengthens the field of the dynamo, and it is evident that the various parts may be so proportioned as to cause the field strength to vary approximately according to the load of the machine. Patent No. 720,661.

Alternating-Current Commutator Motor.—In order to provide speed regulation for small alternating-current motors, such as those used in operating dental engines and other apparatus requiring moderate power and necessarily operated at different speeds, O. H. and Alphonse F. Pieper have devised the arrangement illustrated by Fig. 2 herewith. This consists of an ordinary series-wound commutator motor of the same general type as that used for direct-current work (excepting that the field-magnet circuit is necessarily laminated, of course), in shunt to the brushes of which is connected an adjustable reactance coil. The function of this reactance coil is to regulate the speed of the machine by varying the e.m.f. impressed at the brushes. It will be obvious that a machine of this sort will not run if the brushes are short-circuited, and also that the difference of potential at the brushes will depend upon the reactive voltage of a coil of the kind mentioned connected as shown. With the switch in the position shown in the diagram, the machine runs at maximum speed. This arrangement necessitates the use of a field winding of relatively high self-induction and an armature of relatively low self-induction, partly because the field winding must be able to withstand almost the full e.m.f. of the line when the armature is running at slow speed, and also because the lower the inductance of the armature the better will the regulating reactance coil discharge its function. Patent No. 721,229.

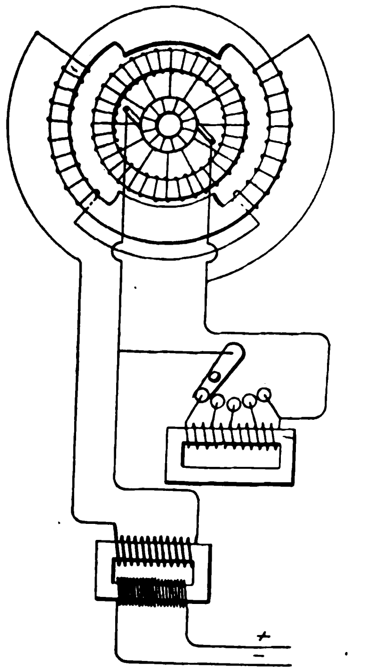


FIG. 2.—ALTERNATING-CURRENT COMMUTATOR MOTOR.

NOTES.

National Electric Light Association.—The twenty-sixth convention of this Association will be held at Chicago, May 26, 27 and 28. The headquarters will be at the Auditorium Hotel. Information concerning special railroad fares, hotel accommodations, etc., can be obtained from Mr. James B. Cahoon, secretary, 136 Liberty Street, New York.

Electrical Engineering Course at Union College.—The electrical engineering course at Union College, Schenectady, N. Y., has been reorganized under the immediate direction and supervision of Mr. Charles P. Steinmetz, chief electrical engineer of the General Electric Company. The conditions at Schenectady for the study of electrical engineering are peculiarly favorable. The works of the General Electric Company are available to the student for opportunities to familiarize himself with apparatus and methods of manufacture.

Municipal Lighting Plant Suggested for New York.—In a report submitted last month by the commissioner of the department of water supply, gas and electricity, dealing with the lighting of New York City, the establishment of a municipal plant for lighting the city streets was strongly advocated. The report was accepted by the Board of Estimate and the commissioner was directed to employ an expert to report on what the cost of an effective municipal electric lighting plant would be. Dr. Cary T. Hutchinson, the well-known consulting engineer, was selected by the commissioner to make the latter report.

Electrical Irrigation.—Electrical machinery is coming to be widely used for purposes of irrigation in the arid regions of the West and is transforming deserts into well-cultivated and productive fields. The Consolidated Canal Company, of Mesa, Ariz., is arranging to furnish water for a large area and is now installing in its power plant a Westinghouse 300-kw. three-phase revolving-field alternator, to run at 400 r.p.m., direct-coupled to a water-wheel; also three 50-h.p. Type C induction motors for 200 volts and 60 cycles, to run at 850 r.p.m. and drive irrigation pumps.

Philadelphia Branch of the A. I. E. E.—The first regular meeting of the Philadelphia Branch of the American Institute of Electrical Engineers was held at the Engineers' Club, 1122 Girard Street, March 9. Mr. Carl Hering was elected chairman, Mr. H. F. Sanville secretary, and Messrs. Charles Hewitt, W. C. L. Eglin, J. F. Stevens, H. A. Foster and Theodore Spencer, members of the executive committee. Mr. W. L. Bliss then presented his paper on "Railroad Train Lighting," which is printed in abstract elsewhere in this issue, and abstracts of papers by Messrs. Farnsworth and Sperry, on the same subject, were read. The next meeting of this branch will be held on Monday night, April 6.

The Iowa Electrical Association will hold its regular annual convention at Davenport, on April 8 and 9, at which meeting the following papers will be read "Maintenance and Operation of Central Stations Operated by Steam Power," by H. T. Fiske, of Muscatine; "Maintenance and Operation of Central of Central Stations Operated by Steam Power," by H. T. Fiske, of Muscatine; "Maintenance and Operation of Central Stations by Water Power," by George S. Carson, of Iowa City; "Feed Water Heaters," by J. A. Innis, of Cedar Grove; "Data for City Pumping by Central Stations," by D. F. McGee, of Red Oak; "Lamp Testing," by J. S. Carson, of Iowa City; "Commercial Rates, Including Fan and Power Rates," by L. L. Kellogg, of Sioux City; "Analysis of the Cost of Street Lighting," by Austin Burt, of Cedar Rapids, and "The Necessity for Grounding Secondary Circuits," by W. J. Greene, of Cedar Rapids. The sessions will be held at the business men's rooms in the Masonic Temple.

The American Electrochemical Society will hold its third annual meeting April 16, 17 and 18 in New York. The sessions will be held in the assembly hall of the Chemists' Club, 108 West 55th Street, and the following papers are scheduled for the meeting: "Constant Voltage and Constant Current Separations," by W. D. Bancroft; "Experimental Study of Some Electrode Effects," by H. T. Barnes; "The Electrolysis of Water," by President J. W. Richards and W. S. Landis; "Experiments with Metallic Diaphragms," by W. D. Bancroft; "The Protective Action of Zinc Chloride on Metallic Iron," by Charles J. Reed; "Insulating Materials, a Field for Chemists," by M. von Recklinghausen; "A Historical Review of the Storage Battery," by H. B. Coho; "The Use of Pyroxyline in Storage Batteries," by Elmer A. Sperry; "The Concentration Changes in the Electrolysis of Brine," by W. H. Walker; "The Influence of Some Impurities in Salt Upon the Yield of Soda by the Amalgam Process," by J. W. Walker; "The Corrosion of Metals by Electrolysis," by A. A. Knudson; "Modern Electrolytic Copper Refining," by Titus Ulke; "Note on the Composition of Electroplating Solutions," by N. S. Keith; "The Formation of Nitric Acid Under Electric Influences," by C. W. Volney; "Note on Electrical Endosmose," by W. D. Bancroft; "Ions and Electrons," by Louis A. Parsons; "Uniformity in Electrochemical Equivalents," by Carl Hering; "Electromotive Force of Alloys," by W. D. Bancroft; "Electrolytic Production of Metallic Compounds," by C. F. Burgess and Carl Hambuechen; "The Electrodeposition of Metals Upon a Rotating Cathode," by J. G. Zimmerman; "Electrolytic Conduction Without Electrodes," by B. A. Marvin; "A New Type of Electrolytic Cell," by P. G. Salom; "Potentials of Zinc in Aqueous Solutions," by H. E. Patten and W. R. Mott; "Notes on Electrolytic Deposition of Nickel," by Woolsey McA. Johnson; "Capacity of Molecules for Electric Charge in Electrolysis," by Alfred H. Cowles.

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

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CONTENTS.

An Application of Gas-Engines to Isolated Plant Work ... 171
Harvesting by Electric Power, by Hamilton Wright ... 172
Transposition and Relative Location of Power and Telephone Wires, by P. M. Lincoln.. 173
The Testing of Insulators, by F. O. Blackwell 174
Circuits for the Transmission and Distribution of Electrical Energy, by A. S. McAllister 175
Remarkable English Engine ... 178
An Electric Car Lighting System, by W. L. Bliss ... 180
Abstracts from Foreign Contemporaries ... 184
Some Recent Electrical Patents ... 186
Notes ... 187
Editorial ... 188
Design for a 15-h.p. Brake Dynamometer, by N. R. Craighill ... 190
Some Hints on the Care and Paralleling of Direct-Current Dynamos, by R. Scott.... 193
Care of Trolley Wheels and Stands, by F. Berry, Jr. ... 194
Boiler Accessories, by C. L. Hubbard ... 194
A Central Energy Multiple Telephone System, by E. T. Evans ... 197
Lessons in Practical Electricity ... 200
Letters on Practical Subjects ... 201
Electrical Catechism ... 203
Queries and Answers ... 204
Control System for the New York Subway Motors ... 205
New Apparatus and Appliances ... 206
New Books ... 209
Obituary ... 210
Personal ... 210
Trade Publications ... 210
Business News ... Adv. 63

Insulation Tests.

In reports of insulation tests, data and diagrams are given which are supposed to show the behavior of insulators or insulating material when subjected to electrical stress. Usually, however, there is no information furnished as to how the tests were made, how long the insulator was subjected to the stress before it broke down, what was the physical condition of the insulator, or how the value of the break-down voltage was obtained. There is no way of telling whether the e.m.f. values given represent effective or maximum voltages, and nothing is said as to how many tests were made. It is scarcely necessary to point out that from test reports lacking the data mentioned no conclusions can be drawn that will be of value for practical use.

In making insulation tests, two general methods are in common use; in one, a step-up transformer (or a series group of transformers) is employed to obtain the desired e.m.f.; in the other, an induction coil is used for the same purpose. In the first case, the potential is measured either by a spark-gauge or by a voltmeter. If a spark-gap is used, considerable doubt must exist as to the correctness of results so obtained, because the arcing distance varies considerably with the amount of moisture in the atmosphere and also with the conditions of the points of the spark-gauge. The voltmeter method is not open to this objection, and is preferable for that reason. In neither case, however, is the form of the wave taken into account, the spark-gauge only giving the maximum value to which the e.m.f. rises, and the voltmeter, the $\sqrt{\text{mean sq.}}$ value. In testing with an induction coil, the spark-gap is used as the measure of the test e.m.f., and, so far as it is an accurate criterion, this method of course makes the maximum e.m.f. the basis of comparison.

It is a well-known fact that an insulator will stand a much higher pressure without breaking down, if the pressure is applied momentarily or for a short time, than it will when subjected to electrical stress for a long time; so that it is not reasonable to assume because an insulator stands, say 50,000 volts, for an instant, that it will be safe to subject it to anything like that pressure for any length of time. The effect of the time element in this case is in a way analogous to that in the case of a piece of material subjected to a repeated mechanical stress, in which case it will fail at a much lower stress per square inch than under a momentary load applied only once. The case of a beam subjected to a transverse load is also roughly analogous; the deflection in time becomes about twice what it is when the load is first applied.

From the foregoing brief discussion it will be evident that there is urgent need for a recognized standard method of making insulation tests, so that tests made by different engineers and at different places may be directly comparable. Among the requirements for such tests should, of course, be the stipulation that the conditions under which the test is made be as far as may be possible identical with those under which the insulator is to be used in practice. Of course, these conditions cannot be duplicated exactly, but they undoubtedly can be approached more closely than it is usually customary to do at the present time; and tests made in such a manner would obviously enable the engineer more intelligently to select an insulator for use where certain requirements are to be fulfilled, and to predict with much more certainty what its behavior will be when in service, than he now can. The suggestions made by Mr. Blackwell in the paper on this subject which appears on another page are most timely and well worth adoption. At all events, some sensible method of testing should be standardized and universally adopted without delay.

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Municipal Lighting Plant Agitation.

Whenever an occasion arises that is favorable to displays of demagoguery, it goes without saying that the public will not be left unentertained by lack of such displays; and it is a notorious fact that nothing produces a more blatant and tiresome class of superficial demagogues than the agitation of municipal ownership. New York has just entered upon what appears likely to prove a wearisome period of activity on the part of this class, brought on by a report made by the Commissioner of lighting and water supply in which the establishment of a municipal plant is advocated. The Commissioner, a most sincere and enthusiastic municipal reformer with high ideals, has fallen at the outset into the common error of drawing comparisons between the cost of lighting in New York and that in small cities where the conditions are radically different. It is an easy matter to prove—on paper—by such methods that the companies engaged in supplying light to the city are revelling in profits that would compare favorably with the "percentage of winnings" of the gentry whose creed is "heads, I win; tails, you lose." The Commissioner's report, however, also makes comparison between New York and the cities of Chicago and Detroit, which is more rational, but which can scarcely be regarded as conclusive in view of the well-known bookkeeping methods customarily applied to municipal plants.

We do not, by any means, take the attitude of apologist for private companies operating lighting and power plants, and if the New York authorities can devise ways and means whereby a municipal plant can be operated here on business principles—or engineering principles, rather—we shall be among the first to tender congratulations. Meanwhile, we do hope it will be possible to choke off the airing of the usual array of specious arguments by wily axe-grinders and the reckless statistical rot of well-meaning but misguided zealots. These cannot in any degree assist the reform administration to work its miracle.

◆◆◆

Composite Electrical Transmission.

The ingenious arrangement of interconnected circuits devised by Dr. Bedell and described in Mr. McAllister's article in this number is a very fascinating one, and contemplation of it leads one into interesting speculations. The behavior of currents in circuits arranged as shown in the article may be roughly explained by saying that the direct (or other superposed) current merely shifts from one wire to the other of the pair constituting one "phase" of the two-phase system, according as the main e.m.f. on the line wires agrees with or opposes it. When the alternating e.m.f. of the two line wires of one phase falls to zero, the superposed current passes over both wires; as the main e.m.f. rises, it opposes the superposed e.m.f. in one wire and agrees with it in the other; consequently the superposed current is shifted more and more from one wire to the other until the main e.m.f. attains its maximum value, when the shifting ceases, and as the main e.m.f. begins to fall, the superposed current begins to shift back again. When the main e.m.f. passes zero, the superposed current begins to shift over to the wire from which it was driven during the previous half cycle.

The flexibility of such an arrangement is beautiful. The superposed current and e.m.f. may be of any character or value whatever, within the limitations of the circuit wires and insulation, without affecting the main alternating current, so that, as intimated in the article, a single-phase medium or high-frequency current for operating lamps may be superposed on a polyphase circuit transmitting 25-cycle currents for power service, with lower actual line loss than with separate circuits containing the same quantity of copper, and with lower inductive drop and better operating results than by using polyphase currents of 60 cycles for both classes of service. Each current acts as though the other were not present, which means that the copper installed for one current may be used by an equal amount of the other current, the drop in e.m.f. in the one case being independently equal to that in the other.

And equally independent regulation is afforded. The same wires which supply current to lamps at an e.m.f. held within a very few per cent of the normal value may simultaneously serve to furnish current to motors at an e.m.f. which may be allowed to fluctuate through any convenient range, perhaps ten times as great as that used at the lamps. Consequently, one current may be used for operating Nernst lamps, which are very sensitive, while the other supplies motors such as those for elevator, crane and similar work, which combination would be absolutely prohibitive on a single circuit of the ordinary character. Again, the existing two-phase distributing lines of a central station may have direct current superposed at any convenient point and taken off at any other point or any number of points, for charging batteries or doing classes of work for which direct current may be considered preferable to alternating currents. Of course the system is susceptible of a large number of modifications, most of which have, equally of course, been worked out by Dr. Bedell.

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Train Lighting Systems.

At a recent meeting of the American Institute of Electrical Engineers several papers were read on the subject of train-lighting systems, one of which is reprinted elsewhere in this issue. The system described appears to be one of the most carefully worked-out among the many that have been suggested; it also serves to bring forward very clearly the fundamental difficulties of the problem and the lengths of complexity to which it is necessary to go in order to meet the requirements of the case. The first condition that confronts an investigator of this problem is that light must be available regardless of train speed, condition of the locomotive, make-up of the train or location of the individual car. In the present state of the art of building prime movers, this means inevitably the use of a storage battery, for the obvious reason that a steam engine-driven unit is inoperative when the car is not coupled to a locomotive or other adequate source of steam. This was found to be the chief disadvantage of the system tried some years ago by the Pullman Company, in which a Brotherhood engine was used to drive a small dynamo.

Having started out with the storage battery auxiliary as an indispensable feature, one immediately finds obstacles arising thick and fast, and the joy of the occasion becomes greatly enhanced when the problem of driving the dynamo is encountered. The several knotty and conflicting points have been disposed of with great ingenuity by Mr. Bliss, as perusal of his paper will show, but the results as to the multiplicity of "working members" and the complexity of the system are such as to cause one to wonder whether or not the end justifies the means. We should think that the responsibility of maintaining five or six complete car equipments of this sort in operating condition throughout a transcontinental "run" would be somewhat onerous. And yet, there apparently is not a superfluous part in the system or one that could be simplified or displaced by something else to advantage.

Here seems to be a field worthy the serious consideration of the explosion engine expert. It is not inconceivable that a gasoline or kerosene engine might be worked out that would prove practical for driving a train-lighting dynamo. By "practical" is meant, of course, a machine that would consent to start whenever the usual methods were applied and would keep in motion for reasonable periods of time under ordinarily intelligent supervision. Such a system would make the lighting plant independent of the locomotive, but it would be difficult of application on the multiple-unit plan; and if it were not so installed it could not in many cases be freed from the storage battery feature, since coaches are frequently switched from one train to another at times when lights are required in them. It might, however, be practicable to provide a single generating outfit for the entire train and install on each car a battery of sufficient capacity to tide over switching and similar periods. This arrangement, too, is practicable with the axle-driven dynamo of the system mentioned above, by modifying the arrangement of circuits, but each car would require one of the motor-driven double-commutator generators which is referred to as the "bucker." In the case of the engine-driven lighting dynamo this would not be necessary. We do not mean to intimate, by any means, that such a system would be more practical than the axle-driven plant; this can only be determined by actual experiment, but the subject appears to be worth investigating.

DESIGN FOR A 15-HORSE-POWER BRAKE DYNAMOMETER.

BY NATHANIEL R. CRAIGHILL.

The friction brake here described and shown by working drawings is intended for use in testing electric motors, gas-engines or other machines the capacity of which does not exceed 15 horse-power. The main parts of the brake are a pulley, an annular tube of rectangular cross-section for holding cooling water, two steel bands to inclose the tube, tension blocks and a hand screw for bringing the ends of the bands together so as to produce friction at the surface of the pulley, and the arm and scale pan for measuring the torque of the motor.

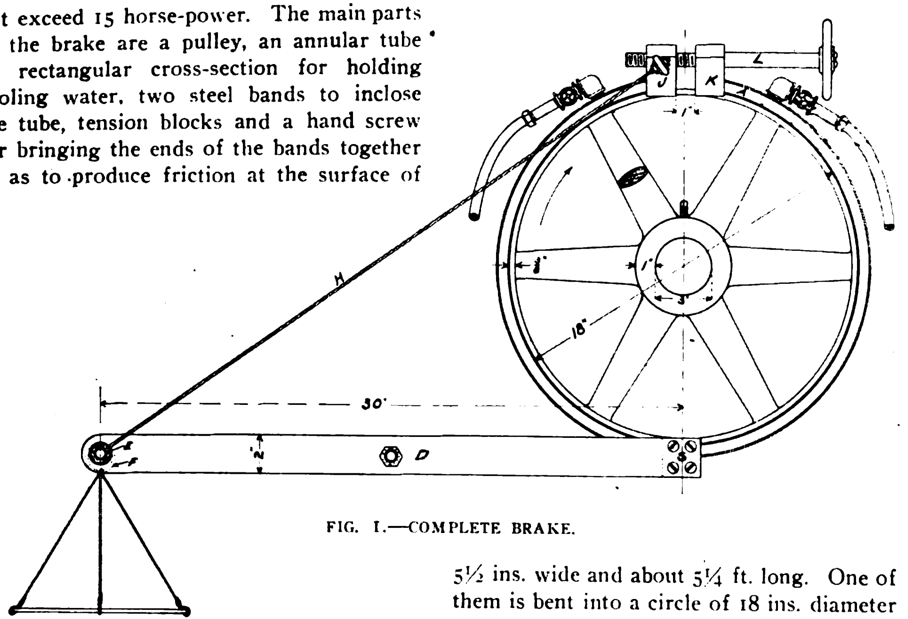

FIG. 1.—COMPLETE BRAKE.

Fig. 1 is an elevation of the complete brake; Fig. 2 is a plan view, and the details are illustrated by the remaining engravings. The pulley is of cast iron, 18 ins. in diameter, with a flat (not crowned) face 6 ins. wide. It has six arms of elliptical section 2 ins. x 13-16 in. at the hub and 1⅜ ins. x 9-16 in. at the rim. The hub is 6 ins long and has an outside diameter of 5 ins. The diameter of the hole through the hub is 3 ins., so as to allow for bushing it to the size of the shaft on the machine to be tested, the bushing to be held in place in the brake pulley by two ⅜-in. set screws and to be keyed to the shaft of the machine, as indicated in Fig. 1.

The annular tube, *A*, is closed at the ends, and is made preferably of thin sheet copper; if this is too expensive, however, one made of tin will answer the purpose. If made of tin, both the inside and outside surfaces should be thoroughly coated with paint to prevent rust. The tube is shown separately in Fig. 5. At a point 3 ins. from each end, a hole 1 in. in diameter is cut, and a nipple of ¾-in. pipe is inserted and secured as shown in Fig. 6. The joint is made watertight by means of two rubber washers, one placed inside and the other outside of the tube. Of course, these nipples must be put in place before the walls of the tube are soldered together.

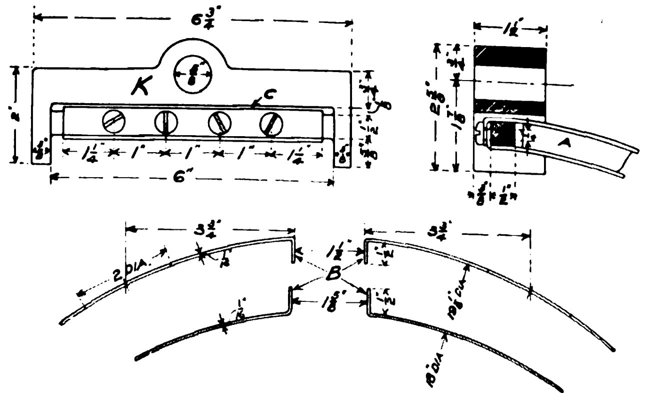

FIG. 3.—DETAILS OF STEEL BANDS AND TENSION BLOCK.

Two steel bands must be provided, each 1-16 in. thick (or of No. 16 Stubs gauge) 5½ ins. wide and about 5¼ ft. long. One of them is bent into a circle of 18 ins. diameter and the ends are bent up so that the distance between them is 1⅝ ins.; the ends are then cut off to a length of ½ in., as shown at *B*, Fig. 3. Holes are drilled in the turned-up ends for ¼-in. screws, spaced as shown in the drawing. The other band is bent into a circle 19⅛ ins. in diameter, and the ends are slipped through the slots, *C*, of the top shoes, and then bent downward so that the distance between them is 1½ ins.; they are cut off to a length of ½ in., as shown at *B* in Fig. 3. A hole 2 ins. in diameter is cut 3¾ ins. from each end. The shoe, *S*, shown at the bottom of the pulley in Fig. 1 and in detail by Fig. 4, is next riveted to the band so that the middle point of it comes half way between the ends of the band. Nine ¼-in. rivets are used to hold it in place, and these are spaced as shown in Fig. 4. The band is then wrapped around the tube, the two nipples projecting through the 2-in. holes. The other band is laid around the inner side of the tube, and the ends of the two bands are brought together and securely fastened to the tension blocks, *J* and *K*, by four ¼-in. screws, as shown in Fig. 3.

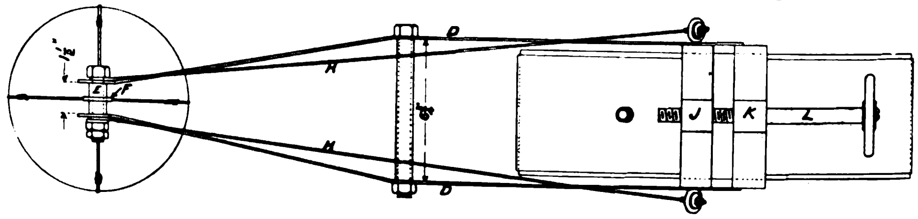

FIG. 2.—PLAN VIEW OF THE BRAKE.

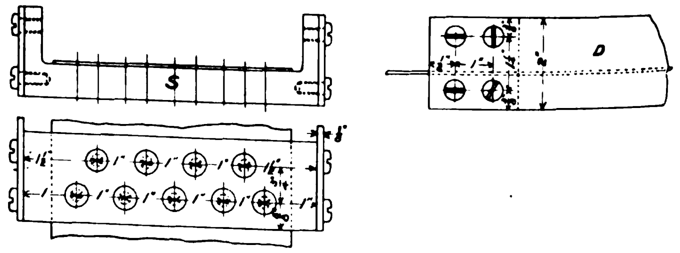

FIG. 4.—DETAILS OF STRESS BLOCK OR SHOE.

The two bars, *D*, *D*, which are of wrought iron, ⅛ in. x 2 ins., may now be put in place. Each is secured to the shoe, *S*, by means of four ¼-in. screws, spaced as shown in Fig. 4. The bars are braced at the middle by means of a ½-in. bolt and a distance piece made of ½-in. pipe, shown in Figs. 1 and 2. Between the ends of the bars there is inserted a piece of ½-in. pipe 1½ ins. long, the outside of which must be previously "skinned" off by means of a light lathe cut, and polished; this piece is indicated by *E* in the drawings. It carries a ring, *F*, 1¼ ins. in inside diameter, made of 3/16-in. round iron, to which are fastened the wires that hold the scale pan. The eyes, *G* (Fig. 10), in the tension wires, *H*, are then put in place against the ends of the pipe, *E*, and the whole is secured by means of a ½-in bolt, as shown in Figs. 1 and 2. Care must be taken to have the horizontal distance from the center of the pulley to the center of this bolt exactly 30 ins., as indicated in Fig. 1. The upper ends of the tension wires may now be passed through the screw eyes in the tension block, *J*, and fastened in place by the nuts, as shown in Figs. 1 and 2. To each of the ¾-in. nipples should be attached an elbow and a globe valve, as shown in Fig. 1.

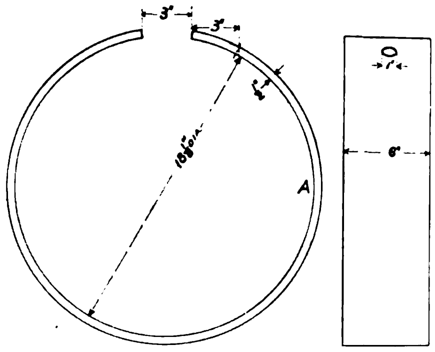

FIG. 5.—DETAILS OF TUBE.

The brake may then be placed in position on the pulley, and the ⅝-in. adjusting screw, *L*, put into place in the tension blocks, *J*. *K*. To each of the globe valves should be fastened a piece of ¾-in. rubber hose pipe; one of these pipes to be attached to a source of water supply and the other to a drain. The next step is to put the pulley on the shaft of the machine the power of which is to be measured. Before making any power measurements, the effect of the weight of the scale pan and supporting parts to the left of the pulley must be determined. To do this, the adjusting screw at the top of the brake must be loosened, and by means of a spring balance attached to the point, *E*, Fig. 1, the number of pounds pull required to hold the lower arm in a horizontal position must be measured; call this number *w*. This is a constant and should be recorded for future reference. Allow water to flow slowly through the tube, the amount being regulated by the globe valves on top of the apparatus.

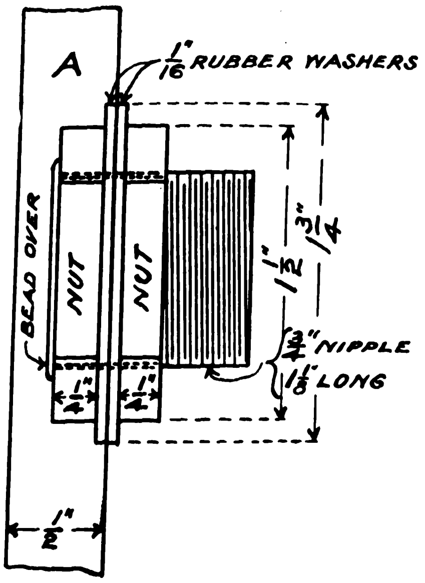

FIG. 6.—DETAILS OF WATER CONNECTION.

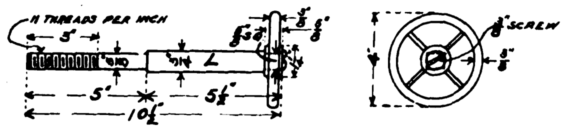

FIG. 8.—DETAILS OF HAND WHEEL.

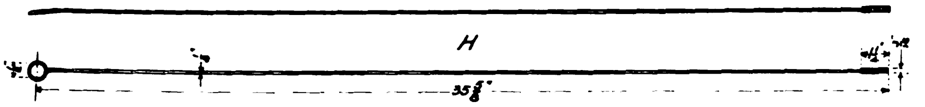

FIG. 10.—TENSION WIRE.

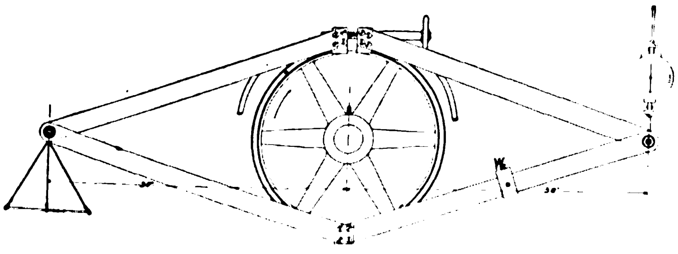

FIG. 12.—DOUBLE-LEVER DYNAMOMETER BRAKE.

Then the machine may be started, the brake bands being drawn against the pulley (by means of the hand wheel, of course) tightly enough to keep the wrought-iron arms horizontal, upper and lower stops being provided to keep the arm from going too far in either direction. A final and more delicate adjustment of the band against the pulley can be made by regulating the water pressure in the tube by means of the two globe valves; the effect of it is the same as that of the steam pressure in an ordinary bourdon gauge, and tends to make the tube assume the form of a circle of larger diameter as the pressure increases. When the machine has settled down to a constant speed, note the revolutions per minute and the weight, *W*, on the scale pan. The formula for horse-power will be

$$\frac{2\pi \times 30 \times (W + w) \times r.p.m.}{12 \times 33{,}000} = h.p.,$$

or simplified,

$$\frac{(W + w) \times r.p.m.}{2100} = h.p.$$

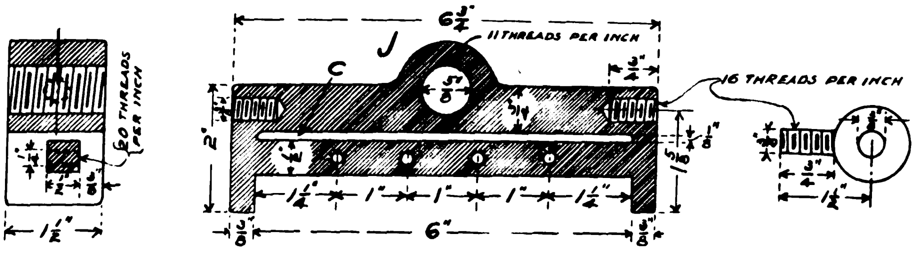

FIG. 7.—DETAILS OF TENSION BLOCK.

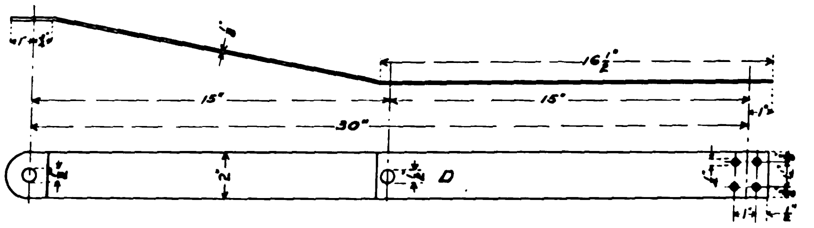

FIG. 9.—DETAILS OF LEVER ARM.

It is usually desired to test a machine for a given horse-power, and in order to facilitate its use in this way a table is given herewith which obviates calculating the weight necessary to use in each case. It must be remembered, however, that the constant, *w*, must be substracted from the weight given in the table corresponding with the speed of the machine and the desired horse-power, in order to ascertain the weight to be placed in the pan. With the proper weight in the pan, the machine is started up and the brake adjusted until the beam is horizontal between the stops and not touching either of them; the machine will then be developing the desired horse-power. If it should be found necessary to lubricate between the inner band and the pulley in order to secure steady friction, a small amount of cylinder oil may be used.

This form of brake has the disadvantage, common to all brakes in the use of which the weight is applied only on one side of the pulley, of increasing the friction on the journal of the machine. This, however, can be corrected by attaching a spring balance to an equal lever at the right, as shown in Fig. 12. Before attaching the spring balance the counterweight, *Wc*, should be adjusted so as to balance the weight of the scale pan and its attachments on the other arm. This eliminates the constant *w*, and the formula becomes

$$\frac{W_t \times r.p.m.}{2100} = h.p.,$$

in which W_t is the sum of the spring bal-

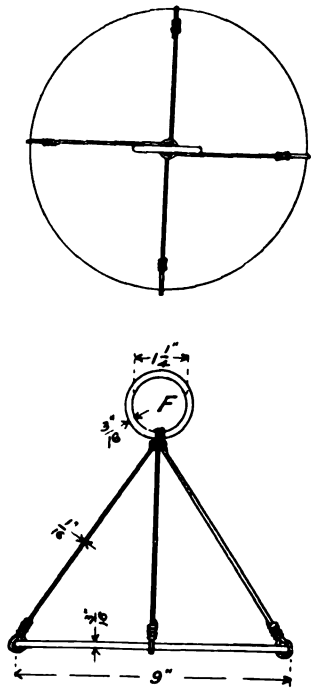

FIG. 11.—SCALE PAN.

ance's pull and the weight on the scale pan. In using the table to test for a given horse-power, therefore, the value of the weight given in the table will be that of W_t and will be correct for the double-lever arrangement of the brake without making the subtraction that is necessary with the single-lever brake.

TABLE II.—PRONY BRAKE.

Giving weights corresponding to different horse-powers and speeds, for a brake arm 30 ins. long. Numbers in body of table are pounds and ounces.

Rev. per Min.	Horse-power delivered to brake: 5	6	7½	8	9	10	12½	15	20	25	30	35	40	45
400	26- 4	31- 8	39- 6	42	47- 4	52- 8	65-10	78-12	105	131- 4	157- 8	183-12	210	236- 4
410	25-10	30-12	38- 7	41	46- 2	51- 4	64- 1	76-14	102- 8	128- 1	153-11	179- 4	204-15	230- 8
420	25	30	37- 8	40	45	50	62- 8	75	100	125	150	175	200	225
425	24-11	29-10	37- 1	39- 9	44- 7	49- 7	61-13	74- 2	98-13	123- 8	148- 4	173	197-11	222- 6
430	24- 7	29- 5	36-10	39- 1	43-15	48-14	61- 1	73- 4	97-11	122- 2	146- 8	170-15	195- 6	219-12
440	23-14	28-10	35-13	38- 3	43	47-12	59-11	71-10	95- 8	119- 5	143- 3	167- 1	190-15	214-11
450	23- 5	28	35	37- 6	42	46-10	58- 6	70	93- 5	116-11	140	163- 5	186-11	210
460	22-13	27- 7	34- 4	36- 9	41- 1	45-10	57- 1	68- 8	91- 5	114- 2	137	159-13	182- 9	205- 7
470	22- 6	26-13	33- 8	35-12	40- 4	44-11	55-14	67	89- 6	111-11	134- 1	156- 6	178-12	201- 1
475	22- 2	26- 9	33- 3	35- 6	39-13	44- 4	55- 4	66- 5	88- 7	110- 9	132-11	154-12	176-14	199
480	21-14	26- 4	32-13	35	39- 6	43-12	54-11	65-10	87- 8	109- 6	131- 4	153- 2	175	196-14
490	21- 7	25-12	32- 3	34- 5	38- 9	42-14	53- 9	64- 5	85-12	107- 2	128- 9	150	171- 7	192-14
500	21	25- 4	31- 8	33-10	37-13	42	52- 8	60- 3	84	105	126	147	168	189
510	20-10	24-12	30-14	32-15	37- 1	41- 3	51- 8	61-12	82- 6	103	123- 9	144- 2	164-12	185- 5
520	20- 3	24- 4	30- 5	32- 5	36- 6	40- 7	50- 8	60-10	80-13	101	121- 3	141- 6	161- 9	181-12
525	20	24	30	32	36	40	50	60	80	100	120	140	160	180
530	19-13	23-12	29-12	31-12	35-11	39-10	49- 8	59- 7	79- 4	99- 1	118-14	138-11	158- 8	178- 5
540	19- 7	23- 6	29- 3	31- 2	35	38-14	48-10	58- 5	77-13	97- 4	116-11	136- 2	155- 9	175
550	19- 2	22-15	28-10	30- 9	34- 6	38- 3	47-12	57- 5	76- 6	95- 8	114- 9	133-11	152-12	171-13
560	18-12	22- 8	28- 2	30	33-12	37- 8	46-14	56- 4	75	93-12	112- 8	131- 4	150	168-12
570	18- 7	22- 2	27-10	29- 8	33- 3	36-14	46- 1	55- 4	73-11	92- 5	110- 9	129	147- 6	165-12
575	18- 4	21-15	27- 7	29- 4	32-14	36- 9	45-11	54-16	73- 1	91- 5	109- 9	127-13	146- 2	164- 6
580	18- 2	21-12	27- 2	29	32-10	36- 4	45- 4	54- 5	72- 7	90- 9	108-10	126-12	144-13	162-15
590	17-13	21- 6	26-12	28- 8	32- 1	35-10	44- 8	53- 7	71- 4	89	106-13	124- 9	142- 6	160- 3
600	17- 8	21	26- 4	28	31- 8	35	43-12	52- 8	70	87- 8	105	122- 8	140	157- 8
610	17- 4	20-11	25-14	27- 9	31	34- 7	43- 1	51-10	68-14	86- 1	103- 5	120- 8	137-11	154-15
620	17	20- 5	25- 7	27- 2	30- 8	33-14	42- 6	50-13	67-12	84-11	101-10	118- 9	135- 8	152- 7
625	16-13	20- 3	25- 4	26-14	30- 4	33-10	42	50- 7	67- 4	84	100-13	117-10	134- 7	151- 4
630	16-11	20	25	26-11	30	33- 6	41-11	50	66-11	83- 6	100	116-11	133- 5	150
640	16- 7	19-11	24-10	26- 4	29- 9	32-13	41- 1	49- 4	65-10	82- 1	98- 8	114-14	131- 4	147-11
650	16- 3	19- 6	24- 4	25-14	29- 1	32- 5	40- 7	48- 8	64-10	80-12	96-15	113- 2	129- 4	145- 6
660	15-15	19- 2	23-14	25- 8	28-11	31-13	39-13	47-12	63-11	79- 9	95- 8	111- 6	127- 4	143- 3
670	15-11	18-13	23- 8	25- 2	28- 4	31- 6	39- 3	47	62-11	78- 6	94- 1	109-12	125- 6	141- 1
675	15- 9	18-11	23- 6	24-14	28	31- 2	38-14	46-11	62- 4	77-13	93- 6	108-14	124- 8	140
680	15- 7	18- 9	23- 3	24-12	27-13	30-14	38-10	46- 5	61-12	77- 4	92- 1	108- 2	123- 8	139
690	15- 4	18- 4	22-13	24- 6	27- 7	30- 7	38- 1	45-11	60-12	76- 2	91- 5	106- 8	121-12	137
700	15	18	22- 8	24	27	30	37- 8	45	60	75	90	105	120	135
710	14-13	17-12	21- 3	23-11	26-10	29- 9	37	44- 6	59- 3	74	88-12	103- 8	118- 5	133- 2
720	14- 9	17- 8	21-14	23- 6	26- 4	29- 3	36- 8	43-12	58- 6	72-15	87- 8	102- 2	116-11	131- 4
725	14- 8	17- 6	21-12	23- 3	26- 1	29	36- 4	43- 8	57-15	72- 7	86-15	101- 6	115-14	130- 6
730	14- 6	17- 4	21- 9	23	25-15	28-12	36	43- 2	57- 9	71-15	86- 5	100-11	115- 1	129- 8
740	14- 3	17- 1	21- 5	22-11	25- 9	28- 6	35- 8	42- 9	56-12	71	85- 2	99- 5	113- 8	127-12
750	14	16-13	21	22- 7	25- 4	28	35	42	56	70	84	98	112	126
760	13-13	16- 9	20-12	22- 2	24-14	27-11	34- 9	41- 7	55- 4	69- 2	82-15	96-12	110- 8	124- 6
770	13-11	16- 6	20- 8	21-13	24- 9	27- 5	34- 2	40- 1	54- 9	68- 3	81-13	95- 8	109- 2	122-12
775	13- 9	16- 4	20- 5	21-11	24- 6	27- 2	33-14	40-11	54- 4	67-12	81- 5	94-14	108- 7	122
780	13- 8	16- 3	20- 3	21- 9	24- 4	26-15	33-11	40- 6	53-14	67- 5	80-12	94- 4	107-11	121- 3
790	13- 5	16	19-15	21- 4	23-15	26- 9	33- 4	39-14	53- 3	66- 8	79-12	93- 1	106- 5	119-10
800	13- 2	15-12	19-11	21	23-10	26- 4	32-13	39- 6	52- 8	65-10	78-12	91-14	105	118- 2
825	12-12	15- 4	19- 2	20- 6	22-15	25- 8	31-13	38- 3	50- 2	63-11	76- 6	89- 2	101-13	114- 9
850	12- 6	14-13	18- 9	19-12	22- 4	24-12	30- 2	37- 1	49- 7	61-12	74- 2	86- 8	98-13	111- 3
875	12	14- 7	18	19- 4	21-10	24	30	36	48	60	72	84	96	108
900	11-11	14	17- 8	18-11	21	23- 6	29- 3	35	46-11	58- 5	70	81-11	93- 6	105
925	11- 6	13-10	17- 1	18- 3	20- 7	22-12	28- 6	34- 1	45- 7	56-12	68- 2	79- 8	90-13	102- 3
950	11- 1	13- 4	16- 9	17-11	19-14	22- 2	27-11	33- 3	44- 4	55- 4	66- 5	77- 6	88- 7	99- 8
975	10-12	12-15	16- 3	17- 4	19- 6	21- 9	26-15	32- 5	43- 2	53-14	64-10	75- 7	86- 3	96-15
1000	10- 8	12-10	15-12	16-13	18-15	21	26- 4	31- 8	42	52- 8	63	73- 8	84	94- 8
1025	10- 4	12- 5	15- 6	16- 6	18- 7	20- 8	25-10	30-12	41	51- 4	61- 8	71-12	82	92- 4
1050	10	12	15	16	18	20	25	30	40	50	60	70	80	90
1075	9-13	11-12	14-11	15-10	17- 9	19- 9	24- 7	29- 5	39- 1	48-14	58-10	68- 6	78- 3	87-15
1100	9- 9	11- 8	14- 5	15- 5	17- 3	19- 2	23-14	28-11	38- 3	47-12	57- 5	66-13	76- 6	85-15
1125	9- 6	11- 4	14	14-15	16-13	18-11	23- 6	28	37- 6	46-11	56	65- 6	74-11	84
1150	9- 2	11	13-11	14-10	16- 7	18- 4	22-13	27- 6	36- 8	45-11	54-13	63-15	73- 1	82- 3
1175	8-15	10-12	13- 7	14- 5	16- 2	17-14	22- 6	26-13	35-12	44-11	53-10	62- 9	71- 8	80- 7
1200	8-12	10- 8	13- 2	14	15-12	17- 8	21-14	26- 4	35	43-12	52- 8	61- 4	70	78-12
1225	8- 9	10- 5	12-14	13-12	15- 7	17- 2	21- 7	25-12	34- 5	42-14	51- 7	60	68- 9	77- 3
1250	8- 7	10	12-10	13- 7	15- 2	16-13	21	25- 4	33-10	42	50- 7	58-13	67- 4	75-10
1275	8- 4	9-14	12- 6	13- 3	14-13	16- 8	20- 1	24-12	32-15	41- 3	49- 7	57-11	65-15	74- 2
1300	8- 1	9-11	12- 2	12-15	14- 9	16- 3	20- 3	24- 4	32- 5	40- 7	48- 8	56- 9	64-10	72-12
1325	7-15	9- 8	11-14	12-11	14- 4	15-14	19-13	23-12	31-12	39-10	47- 9	55- 8	63- 7	71- 5
1350	7-13	9- 5	11-11	12- 7	14	15- 9	19- 7	23- 5	31- 2	38-14	46-11	54- 7	62- 4	70
1375	7-10	9- 3	11- 8	12- 4	13-12	15- 4	19- 2	22-15	30- 9	38- 3	45-13	53- 8	61- 2	68-12
1400	7- 8	9	11- 4	12	13- 8	15	18-12	22- 8	30	37- 8	45	52- 8	60	67- 8

The double-lever arrangement is greatly preferable to the single-lever brake, and can be built about as easily. Since with the single-lever arrangement the shaft of the machine is subjected to the downward pull of the weights in the scale pan in addition to the weight of the entire apparatus, it is inadvisable to use it for testing machines larger than 15 to 18 horse-power. The double-lever brake is limited chiefly by the amount of heat that can be got rid of safely at the friction surfaces, and if built according to the directions given for the construction of the single-lever brake, and with arms of the same size and material as the two arms, *D*, *D*, of the single-lever apparatus, it may be used for measuring up to 35 horse-power at any speed not lower than 500 r.p.m., or 40 horse-power at any speed above 550 r.p.m. So far as strength is concerned, it will serve for any work requiring not more than 75 pounds pull on the end of each lever.

SOME HINTS ON THE CARE AND PARALLELING OF DIRECT-CURRENT DYAMOS.

BY RALPH SCOTT.

Although direct-current machines are relatively very simple and familiar to every electrician, yet multiple running is sometimes fraught with difficulties that manifest themselves in a very forcible manner. In the case of new machines, the first thing to do is to dry out the armature thoroughly, the best method being to run the armature at full speed, connect a 16-c.p. or 32-c.p. incandescent lamp in series with the shunt field, and short-circuit the armature at the brushes, care being taken that the current does not exceed the full-load current of the machine. After several hours of such running the insulation resistance of the machine should be tested. The following method is a handy one: Connect a voltmeter having a known resistance (which is generally marked on the dial in ohms) to both terminals of the machine and note the reading in volts, which should be the full voltage of the machine. Now remove one voltmeter wire and ground it on the frame of the machine for five minutes. Note the deflection at this time. The insulation resistance, R, will then be

$$R = \frac{E \times r}{v} - r,$$

where E equals the full voltage of the machine, r the resistance of the voltmeter, and v the voltage when grounded on the frame. This resistance R should be from ½ to ¾ megohm for a 100-kw. machine, decreasing with larger sizes. If this figure is not reached the first time, the drying process should be continued. If the resistance (insulation) of the field winding is low, the coils should be dried in an oven or over a boiler. In case of a machine being soaked with water in any manner, as by a flood, never attempt to run the machine before *thoroughly* drying both the armature and the field coils in an oven. Trouble is especially experienced with water between the commutator segments, and at this place it is almost impossible to remove it except by long continued drying. Sometimes it is expedient to unsolder the conductor leads from the lugs, remove the commutator, and submit it to a temperature of about 280 degrees, which temperature will drive all water out, but would be injurious to the cotton insulation on the armature conductors.

Any humming, sparking or poor regulating should be carefully noted, for it is very important to have in mind the characteristics of each machine before attempting to parallel them. The next requirement is to know positively the polarity of the terminals of each machine. Although these are generally marked, there is a possibility of their having been reversed. For this purpose, take a piece of blotting paper, dip it in a saturated solution of potassium iodide in water and place the testing wires on this paper about ¾ inch apart for each 100 volts of e.m.f. The positive wire will leave a brownish mark, while the negative will leave none at all. This test is absolutely reliable, and it is preferable to voltmeter and other tests.

With machines like the Thompson-Ryan it is necessary to have the terminal marked + always positive for the following reason: Referring to the accompanying sketch, S is the series winding and F, F' the pole-piece. The tendency of the armature reaction, with an increase in load, is to force the magnetic flux to the pole-tip marked F. The tendency of the series winding is to produce a preponderance of lines of force in the pole-tip F'. The resultant of these tendencies is to produce a uniform distribution of the lines of force over the whole pole-piece. Suppose, however, the direction of the current be reversed, it will be evident that the tendency of an increase in load will be to force all the lines of force to the pole-tip F'. With this connection the sparking will be excessive, while with the series winding properly connected there is no sparking whatever between wide ranges in load. The action of this machine in parallel with the ordinary type is poor indeed, and under equal conditions it results in the simple type of machine taking the larger share of the load.

The question of compounding is a very important one. If the machines are over-compounded, any load at the end of a long line or circuit may receive a uniform voltage, while a load near the machine may be subjected to an excessive voltage. For motors and arc lamps this may not be detrimental, but for incandescent lamps it is, of course, highly objectionable. A little over-compounding is no detriment with a constant load, as lamps of higher voltage may be used near the station, but with motors and lamps on the same circuit it should never be allowed.

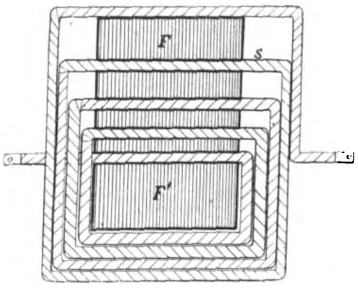

FIG. 1.—THOMPSON-RYAN SERIES WINDING.

The question may arise in an isolated plant with a combined motor and lamp load, "Is it better to parallel dynamos or to use double-throw switches on the switchboard?" As the switchboard is generally situated in the engine-room, and the engineer in most cases is also the electrician, double-throw switches are undoubtedly best for the following reasons: The generators (assuming there are two) may be different in design and characteristics without causing trouble; no equalizer switches, bus-bar, or cables are required; no mistakes such as short-circuits, etc., caused by "no voltage" on one machine, can be made; anyone can manipulate the circuits, and each machine may be loaded as desired. While more attention is required with double-throw switches, yet the engineer may give this without necessarily being kept from other duties. With machines made by the same builder and of the same type, paralleling is a simple matter, but when the new machine is of an entirely different type from the old one, difficulties are inevitable.

Another good plan is to have all motors, as far as it is possible, started from the switchboard, or at a separate board, by the engineer or some other experienced person, as this may effect a great saving in repairs to rheostats, cut-outs and switches, misused by having motors started by inexperienced hands.

A very important feature in parallel operation is the equalizer. Its resistance should be as low as possible. Where the distance between one machine and the board, plus the distance between the other machine and the board, is not over 100 feet, the equalizer may be of the same cross-section as the main dynamo cables, but if it is greater than this its cross-section should be more. No joints should be permitted, or anything that will tend to increase its resistance; if the resistance of the equalizer circuit is increased in any way its function—keeping the series field excitation of each machine constantly proportional—will be impaired. Since the e.m.f. causing the flow of current through the equalizer circuit is very low, a slight increase in its resistance, such as would be caused by a poor switch contact, for example, will be sufficient to reduce the equalizing current seriously.

Although it is sometimes cheaper to use a separate single-pole switch for the equalizer on the switchboard, an undoubtedly better plan is to use three-pole main switches, as by the latter method no harm can result by leaving the equalizer switch open, as would occur with a great difference in voltage in the separate machines when thrown together. The machines may be permanently connected with an equalizer without a switch, but in the case of 500-volt machines on grounded circuits, this may lead to unpleasant shocks when working around a machine at rest.

Trouble is sometimes experienced with paralleled machines the field-magnets of which are built of different varieties of iron. Laminated cores are very sensitive; that is, with a given change in field current the magnetism is affected almost immediately, while with cast-iron cores the change is not so sudden, the flux appearing to have a sort of inertia. With a quick change in load, when one machine has cast and the other laminated magnet cores, the greater load will be taken momentarily by the laminated machine for the reason that its series field builds up very quickly. With a laminated machine having under-compounding, the reverse effect will follow.

With two machines of this sort connected in parallel, various peculiar effects occur. Suppose a motor to be started. The laminated field machine will at first deliver an excessive current; after a few seconds the other machine will pick up both in speed and field excitation and will probably force some current backward through the laminated machine. By noting the voltmeters and ammeters at this time they will be found moving back and forth, while the changes in field flux will produce a peculiar singing noise. A hunting governor on either engine driving the machine will produce the same effect.

Just here, it may be worth while to digress sufficiently to say that a prolific cause of governor hunting is dirt or waste in the opening of the governor dashpot. Sometimes heavy oil or a grain of sand will produce the same effect. For this reason the dashpots should be kept free from dirt or unnecessary oil. No lost motion between the dashpot rod and the part it is connected to should be tolerated. The moving elements, both piston and rocker, should work easily.

In multiple running, it is important that the brushes should be in the right position. Surgings of current from one machine to the other cause excessive sparking if the brushes are not set right. Sparking may occur at one or more sets of brushes, due to their being shorter or longer than the rest, throwing them slightly out of their correct position. A machine heavily loaded will spark with a very slight movement of the brush rigging. In the Thompson-Ryan, or other split-field machines, excessive sparking in proportion to the load will result if the field be reversed in any way, as by a reversal of rotation or changing the shunt field connections. The commutator may even score or be burned to a depth of 1/16 inch by a single day of running in this manner. The scoring will occur on one side of each segment; that is, on the "following" side relative to the direction of rotation.

Pressure on the brushes should be as light as possible. Too great pressure not only wears both brushes and commutator, but also heats the whole commutator and increases the heating of the armature. Ample brush area should be allowed; about 30 amperes per square inch per terminal for carbon, and 150 amperes for copper are practical figures. Gauze brushes should be of larger cross-section than leaf copper for the same current. All brushes on one machine should be of the same kind and size. If commutator compound is used, it should be put on very sparingly when the machine is running without load.

In the case of a heavily loaded machine, it is a good plan to arrange two fans at the commutator end and force a blast of air toward the armature. The amount of heat that may be dissipated in this manner is surprising.

When the machines are in multiple the voltage may be changed by either field rheostat (the division of load between the machines will also be affected by manipulating only one rheostat). In throwing out, however, the separate voltages will change accordingly as the rheostats are set. Therefore one should be careful, in throwing out, that the voltage of the single machine may be neither too high nor too low. In throwing in multiple the voltages of the machines may differ by about 5 per cent without causing any injury.

CARE OF TROLLEY WHEELS AND STANDS.

BY FRANK BERRY, JR.

The tension applied to a trolley pole is a very important factor in the life of both the trolley wheel and the wire. The life of a trolley wheel is, of course, affected by the pressure with which the trolley wheel is held against the wire, by the amount of current that it passes, and by the grade of material of which it is made. The tension springs on the trolley stand should always be so adjusted as to give the trolley wheel a firm contact against the trolley wire at that point on the road where the wire is at its greatest height above the roadbed, and no more, as excessive tension will lessen the life of the trolley wheel a considerable number of miles, besides wastefully cutting the trolley wire. No specific rule can be set down for the proper amount of tension to give a trolley pole, as under some conditions of operation heavy trolley wheels are required, and then more spring tension is, of course, required to produce the required degree of pressure against the trolley wire than if a lighter wheel were used.

It is a well known fact that the motorman's methods very greatly affect the life of a trolley wheel. For instance, if a motorman is careless about going over section breakers, frogs and crossings, and allows the power to remain on when it should be off, destructive arcing will occur which will make flat spots on the trolley wheel, and these cause worse arcing by improper contact and rapidly wear out the trolley wheel.

The fit of the trolley wheel in the trolley harp also affects the good running qualities of the wheel. A newly bushed trolley wheel should fit easily over the axle pin and the end play should be taken up by threading on copper washers, leaving, of course, enough end play to prevent the trolley wheel from wearing a ridge in the axle. Trolley-wheel axles, when they become unduly worn, should not be used, as they chew up the trolley bushings, and a wheel should, of course, be discarded before it splits in half, as the wear on both the trolley axle and trolley wire is increased by allowing it to run too long.

Although an anti-friction metal is used in the trolley bushing, a little oil applied occasionally will increase the life of the bushing. As previously stated, the life of a trolley wheel depends partly upon the amount of current that the wheel has to pass. On cars, for which the amount of current required has been increased, the life of the trolley wheel will be decreased. It is important, therefore, to use trolley wheels of a diameter large enough to give ample contact surface on the trolley wire for the amount of current that is to be passed at the outset, then no serious trouble will develop if the current is afterwards increased. The proper diameter for any case can really be determined only by actual experiment, taking complete notes of the behavior of each of several sizes of wheel during a series of trial runs.

BOILER ACCESSORIES.

BY CHAS. L. HUBBARD.

Boiler feed water, especially if cold, should be discharged into the boiler in a manner to secure the least possible cooling effect upon the hot plates and tubes. The more common method is to enter the feed pipe through the front head just above the tubes and extend it to a point about two feet from the rear head, then across and downward between the shell and the tubes, discharging the feed water into the cooler part of the boiler. The end of the pipe is sometimes plugged, and the water is discharged through small holes drilled in the sides of the pipe, which gives a more even distribution of the cooler water. Other devices are sometimes used by means of which the water is thrown into the steam space in the form of a spray. This has the disadvantage of condensing part of the steam and reducing the pressure, this result being especially noticeable if large quantities of cold water are fed into the boiler at one time.

That part of the feed pipe within the boiler is usually of brass, while the connections exposed in the smoke bonnet should be of extra heavy wrought iron. Fig. 1 shows a common method of connecting the feed pipe with the boiler; here, *A* is a bushing screwed through the tube sheet, and into this is screwed the brass pipe *B* from the inside and the iron pipe *C* from the outside. Connection is sometimes made through the top of the shell in a similar manner. The branch pipe to each boiler should be provided with a gate or globe valve and a check valve; the former being placed next to the boiler. When several boilers are fed from a single main it is better to supply them all at the same time, regulating the flow to each boiler by the hand valve in its supply pipe. Table I gives suitable sizes of feed pipe for boilers of different diameter.

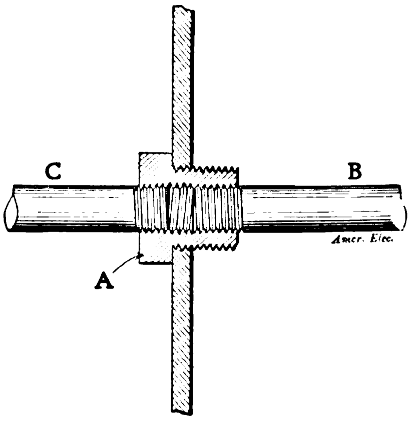

FIG. 1.—FEED-PIPE CONNECTION.

The blow-off pipe is commonly tapped into the boiler shell at its lowest point near the rear head. A circular plate of the same material as the boiler head and from ½ inch to ⅝ inch thick is riveted to the shell to reinforce it where the blow-off pipe is connected. A gate valve and asbestos packed cock are connected into the pipe, outside of the setting, the valve being placed next to the boiler as in the case of the feed pipe. Special blow-off valves, so designed as to prevent the catching of sediment beneath the seat, are sometimes substituted in place of the valve and cock.

Fig. 2 shows a method of making the gravity return and blow-off connections for a pair of boilers. From the arrangement of valves it will be seen that each boiler is entirely independent of the other so far as blowing off or receiving condensation is concerned. A check valve placed in the main return, as shown, prevents the water from being blown out of the boiler, and still allows communication between the two boilers, thus maintaining the same water level in both. When the return connections are made in this way it is advisable to connect the two boilers by means of an equalizing pipe of good size attached to the front nozzles so as to maintain an equal pressure in each and prevent syphoning from one boiler to the other. Table II gives suitable sizes of blow-off connections for boilers of different diameters. When the pipe acts also as a gravity return for the condensation from a heating system it is commonly made somewhat larger; the sizes for such cases are given in the right-hand column of the table.

TABLE I.—Sizes of Feed Pipes.

Diameter of boiler.	Size of feed pipe.	Size of bushing.
30 inches 36 inches 42 inches 48 inches	1 inch	1½ inches
54 inches	1¼ inches	2 inches
60 inches	1¼ inches	2 inches
66 inches	1½ inches	2½ inches
72 inches	1½ inches	2½ inches

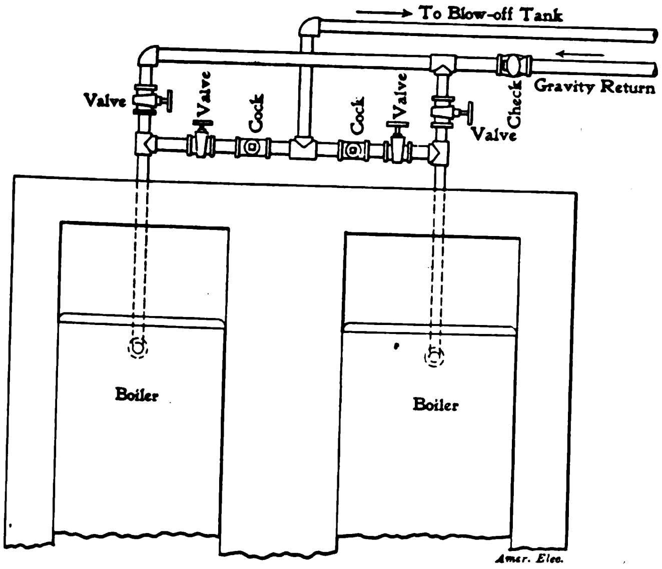

FIG. 2.—GRAVITY RETURN AND BLOW-OFF CONNECTIONS.

TABLE II.—Blow-off Pipes.

Diameter of boiler.	Size of blow-off pipe	Size of pipe for gravity return.
30 inches	1¼ inches	1½ inches
36 inches	1¼ inches	1½ inches
42 inches	1½ inches	2 inches
48 inches	1½ inches	2 inches
54 inches	2 inches	2½ inches
60 inches	2 inches	2½ inches
66 inches	2½ inches	3 inches
72 inches	2½ inches	3 inches

Different methods are used for protecting the blow-off pipe where it is exposed to the fire in the combustion chamber. In most water-tube boilers the blow-off pipe is located well away from the hottest part of the fire, so that it is only necessary to consider here the blow-off pipe of a tubular boiler. Fig. 3 shows a connection commonly found, especially in heating plants. This is objectionable because the pipe and connections are exposed directly to the hot gases as they pass over the bridge wall, and as there is practically no circulation in the pipe the metal is liable to become overheated and the pipe to burst. If the returns in a heating system are brought back to the boiler through this pipe, a circulation is set up which greatly lessens any liability to damage from overheating. Fig. 4 shows a much better arrangement. In this case the pipe is carried down through the paving and then carried outside the setting, as shown. The part exposed to the fire is encased in a cast-iron sleeve, and the space between the sleeve and pipe is packed with some non-conducting material like asbestos or mineral wool.

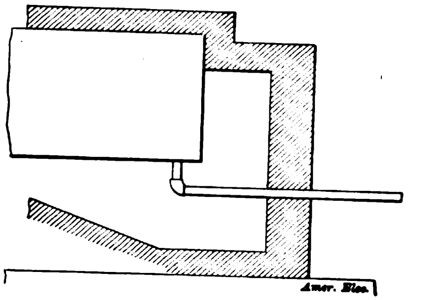

FIG. 3.—BLOW-OFF PIPE CONNECTION.

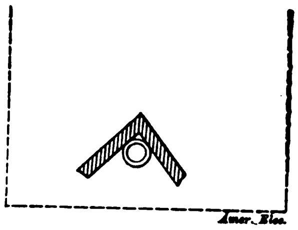

FIG. 6.—FIRE-BRICK SHIELD.

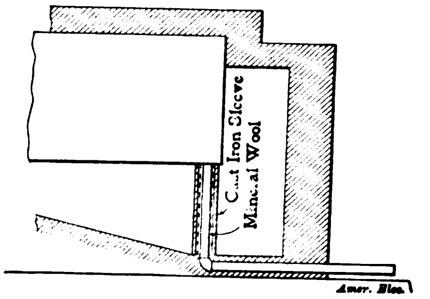

FIG. 4.—BLOW-OFF PIPE CONNECTION.

The arrangement shown in Fig. 5 has a circulation pipe which keeps up a movement of the water and thus prevents overheating. Still further protection may be provided by placing cast-iron sleeves upon one or both of the pipes exposed within the setting. Another method sometimes used is shown in Fig. 6. This consists of a V-shaped shield of fire-brick built around the pipe on the side next to the fire. The principal advantage of this is that it leaves the pipe open for inspection at all times through the back connection doors.

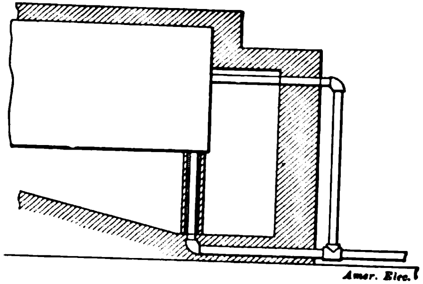

FIG. 5.—BLOW-OFF PIPE CONNECTION.

Where the blow-off delivers into a sewer, some means must be employed for cooling the water discharged from the boiler, or else the joints in the earthen sewer pipes will be injured. This is accomplished by passing the water through a so-called blow-off tank, one form of which is shown in Fig. 7. This consists of a closed receiver *A*, connected with the boiler by the pipe *B*. The tank ordinarily stands full of cold water. When hot water is admitted from the boiler, any steam that is present will be carried off through the vapor pipe *C*, which should extend through the roof. As the hot water enters the top of the tank, the cold water will be forced out from the bottom through the discharge pipe *D*, which connects with the sewer. A small cross-connection, *E*, is provided for admitting air pressure to the discharge pipe to break the syphon effect and prevent the tank from being drained after the blow-off valve in the pipe *B* is closed.

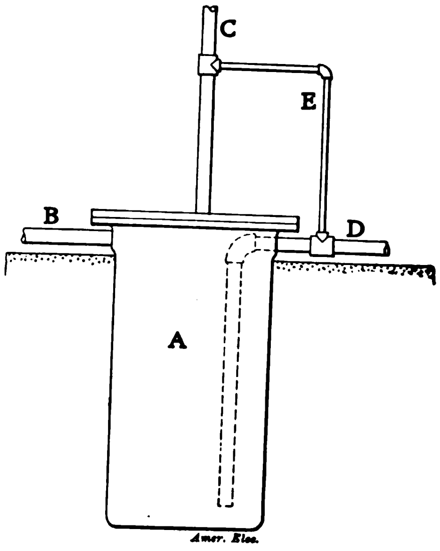

FIG. 7.—BLOW-OFF TANK.

This form of tank is made of cast-iron and is usually sunk so its top is flush with the boiler-room floor or slightly above it.

Fig. 8 shows a tank of boiler iron made to rest upon cast-iron cradles. The principle is the same, and the reference letters indicate the same parts as in Fig. 7. There are in addition a pipe, *F*, for draining the tank, and another cross-connection, *G*, to be used for draining the boiler in case it is lower than the top of the tank. A manhole should be placed in the shell on top and a handhole in each end. Tanks of this description are usually made of iron ¼ inch thick, with single riveted joints.

The size of the blow-off tank depends upon the amount of water it is desired to remove from the boiler at one time. It is customary to blow out a small quantity at frequent intervals, and for this purpose it is usually found sufficient to make the volume of the tank about one twenty-fourth that of the boiler. If there are two boilers, the tank is made twice as large as for one of course, and so on up to the maximum number of boilers it is desired to blow off at one time. In a battery of several boilers, they would probably be blown off two or three at a time, so that the tank would not need to be one twenty-fourth of the aggregate volume of *all* the boilers. If it should be desired to completely drain a boiler, it should be cooled down to a temperature below that which is injurious to the sewer pipe before blowing off, since hot water would pass on through the tank after it had been once filled.

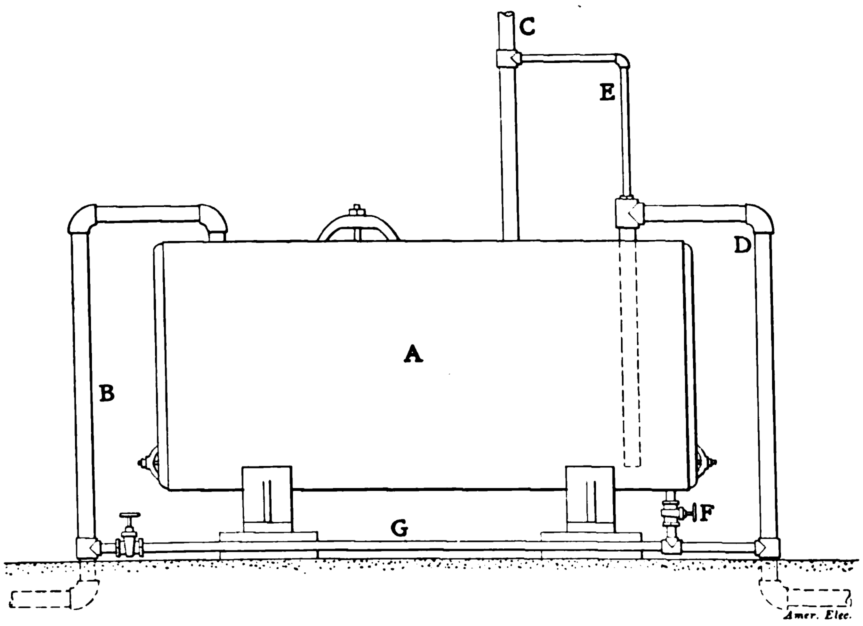

FIG. 8.—BLOW-OFF TANK.

The fusible or safety plug of a boiler consists of a brass bushing with a core of some fusible metal which melts before an excessive temperature is reached. In a cylindrical tubular boiler the fusible plug is screwed into the rear head at a point from two to three inches above the upper row of tubes. To be efficient, the plug should be of good length and the core made tapering in form, with its larger end toward the steam pressure, in order to prevent being blown out. Although fusible plugs are in general use, their value as safety devices is somewhat doubtful and too much reliance should not be placed upon them.

Table III gives the sizes of steam pipe connections that have been found to work satisfactorily in connection with heating plants, and can be safely adopted for this class of work. These are proportioned for the maximum length of the various diameters of boilers and are therefore somewhat larger than is necessary for the shorter lengths; but the discrepancy is on the side of safety and the table is sufficiently accurate for ordinary purposes. For power boilers the requirements are somewhat different, depending upon the size of the engine supply pipe, length of run, etc. In case the engine is some distance from the boiler, it is good practice to make the pipe one size larger than called for by the engine and reduce near the throttle valve. Column 3 gives the size of lever safety valve that may be used with the different sizes of boilers.

TABLE III.

Diameter of boiler.	Size of steam pipe.	Size of safety valve.
30 inches	3 inches	2 inches
36 inches	3½ inches	2½ inches
42 inches	3½ inches	2½ inches
48 inches	4 inches	3½ inches
54 inches	5 inches	4 inches
60 inches	5 inches	4 inches
66 inches	6 inches	5 inches
72 inches	6 inches	5 inches

TABLE IV.

Size of safety valve.	Horse-power of boiler.
1 inch	5 to 10
1¼ inch	10 to 20
1½ inch	20 to 30
2 inch	30 to 40
2½ inch	40 to 75
3 inch	75 to 100
3½ inch	100 to 125
4 inch	125 to 150
5 inch	175 to 200

There are several rules for determining the size of safety valve, each giving a different result. Kent gives a comparison of the results obtained by different methods of calculation for a 100-h.p. boiler in which the required areas vary from 5.25 to 57.6 square inches. Table IV. gives sizes of pop safety valves which correspond well with the average results obtained from the most approved methods of calculation and with the sizes recommended by some of the leading makers.

When a diameter of over 4 inches is required, it is better to use two smaller valves having an equivalent total capacity. In high-pressure plants a pipe should be connected to the safety valve discharge orifice and carried out of doors to prevent filling the boiler-room with steam when the boiler is blowing off. This should also be done on low-pressure systems if the boilers are of good size and the boiler-room small.

The water-glass connections and gauge cocks may be tapped directly into the front head of the boiler or into a cast-iron column, which in turn is connected at top and bottom with the boiler by 1¼-in. pipes. A ½-in. or ¾-in. drip connection should be made between the bottom connection of the water column and the ash pit, for blowing out any sediment which may collect in this pipe. The water-glass should, of course, be so connected that it can be shut off in case of breakage; it should also be provided with a blow-off cock at the bottom. It is customary to locate the bottom of the glass at a level about two inches above the top of the upper row of tubes, although it is sometimes set on a level with the tubes; the former method is the better, as the water will then disappear in the glass before it falls low enough in the boiler to leave the tubes uncovered.

The middle gauge cock is set on a level with the normal water line of the boiler, and the others are located, one about three inches above and the other the same distance below. The smoke connection between the boiler and chimney is usually made of No. 10 or 12 black iron for sizes up to 30 or 36 inches in diameter. It may be either round or rectangular in section, although the former is preferable, especially for the smaller sizes, and is more efficient for a given area as the corners in a square pipe are of little value. The larger sizes of rectangular pipe should be stiffened by riveting angle irons in the corners. Doors of suitable size should be placed in the pipe at intervals to give access for cleaning. These are usually placed near bends in the pipe, as the soot and ashes are more apt to collect at such points.

Where two or more boilers are connected with the same smoke pipe there should be an adjustable damper for hand regulation in each up-take, in addition to a balanced damper in the main pipe, controlled by an automatic damper regulator. This main damper should be provided with roller bearings to secure an easy movement, and should set at an angle of 45 degrees when closed in order to reduce the range of motion through which the damper regulator must move in operating it. In the case of a single boiler, the hand damper in the up-take would be omitted.

A CENTRAL ENERGY MULTIPLE TELEPHONE SYSTEM.

BY E. T. EVANS.

The central energy multiple telephone system, the operation of which it is the object of this article to explain, is at present in use in an exchange having about 3,000 subscribers. The diagrams presented herewith have been simplified as much as possible, all details not required for a clear understanding of the operation being omitted. In Fig. 1 is shown the apparatus in the line circuit at the exchange and one subscriber's circuit. It will be seen that the ground is used as a return circuit for ringing the subscriber's bell, but when talking the ground is disconnected at the subscriber's station and communication is effected over a complete metallic circuit. There are, of course, as many multiple jacks as there are sections in the switchboard, but in the diagram only one multiple jack is shown. It will be seen that line wire *1* is in series with the line relay, R_5, which has a resistance of 250 ohms and requires about .05 ampere for its operation. This relay is cut out during conversation and therefore need not be, and is not, an iron-clad relay. Its armature when attracted closes two circuits, one through the line lamp, L_1, which is of about ⅓ candle-power and requires about 0.1 ampere, and the other through a line pilot lamp, L_2, and an ordinary pony Morse relay that require about ¼ ampere to operate them.

There is one line pilot lamp and one Morse relay for each operator's position at the switchboard. The pilot lamp, as will be shown later, assists the monitor operator to watch the work of the operators because it lights every time any line lamp in that section lights and stays lighted until the operator answers the call. All the contacts, *p*, of the relays belonging to one operator's position are connected together at the point *12*. The Morse relay controls a buzzer of 500 ohms resistance, in the circuit of which is a switch, *Sw*, which is closed only at night or at other times when an operator has to take care of a large number of sections. With the switch closed, the buzzer will sound whenever one of the line relays is operated. There is only one line buzzer for the entire exchange, the contacts of all the Morse relays being joined together at the point *15*. The cut-off relay is a tubular or iron-clad relay having a resistance of 250 ohms. It is connected across the circuit during conversations and hence must have a very high impedance.

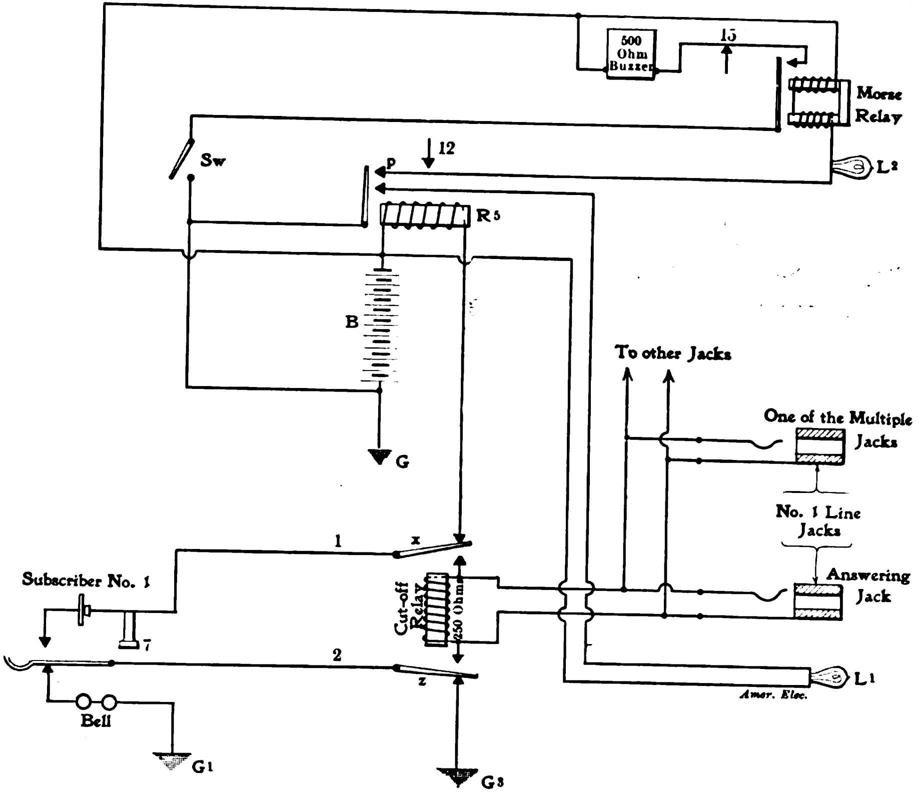
500 Ohm Buzzer
15
Morse Relay
Sw
12
p
R5
L2
B
G
To other Jacks
One of the Multiple Jacks
No. 1 Line Jacks
Answering Jack
1
x
Subscriber No. 1
Cut-off Relay
250 Ohms
7
2
z
Bell
G1
G3
L1
Amer. Elec.

FIG. 1.—NORMAL CONDITION OF LINE CIRCUIT.

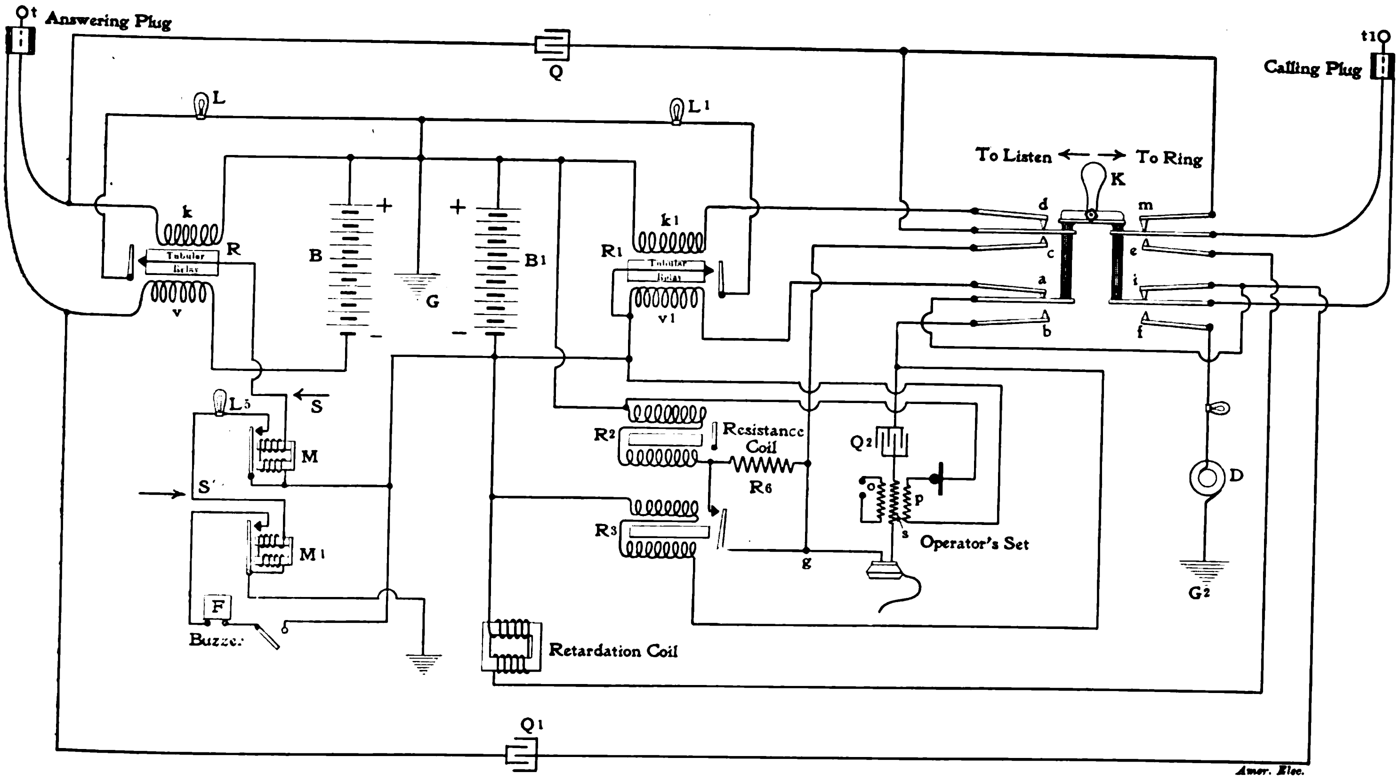
t Answering Plug
Q
t1 Calling Plug
L
L1
To Listen
To Ring
K
k
R
Tubular Relay
v
B
+
-
G
B1
k1
R1
Tubular Relay
v1
d
m
c
e
a
i
b
f
L5
S
M
S'
M1
F
Buzzer
R2
Resistance Coil
R6
R3
Q2
o
p
s
Operator's Set
g
D
G2
Retardation Coil
Q1
Amer. Elec.

FIG. 2.—OPERATOR'S CORD CIRCUIT.

It will be noticed that the jacks are very simple, having only two wires running to them and two contacts, a tip spring and sleeve contact. The subscriber signals the exchange by removing his receiver from the hook, as usual in central energy exchanges. This disconnects line wire *2* from the bell and ground, and connects it through the transmitter and receiver to the wire *1*. This allows sufficient current to flow from the central battery, *B*, through grounds *G* and G_2, armature *z*, line *2*, hook switch, transmitter, receiver, line *1*, armature *x*, and line relay R_5, back to *B*. The line relay is thus energized and connects the battery with the line lamp and pilot lamp. The line lamp, therefore, lights up and the operator knows that a connection is desired, and the pilot lamp also lights. The Morse relay, of course, is energized, and if the switch *Sw* is closed current will flow through the buzzer.

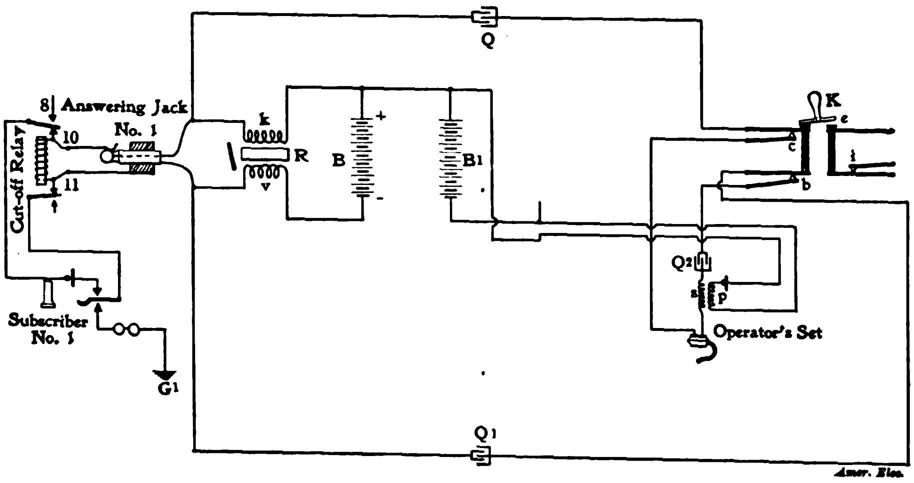

FIG. 3.—DIAGRAM OF ANSWERING CONNECTIONS.

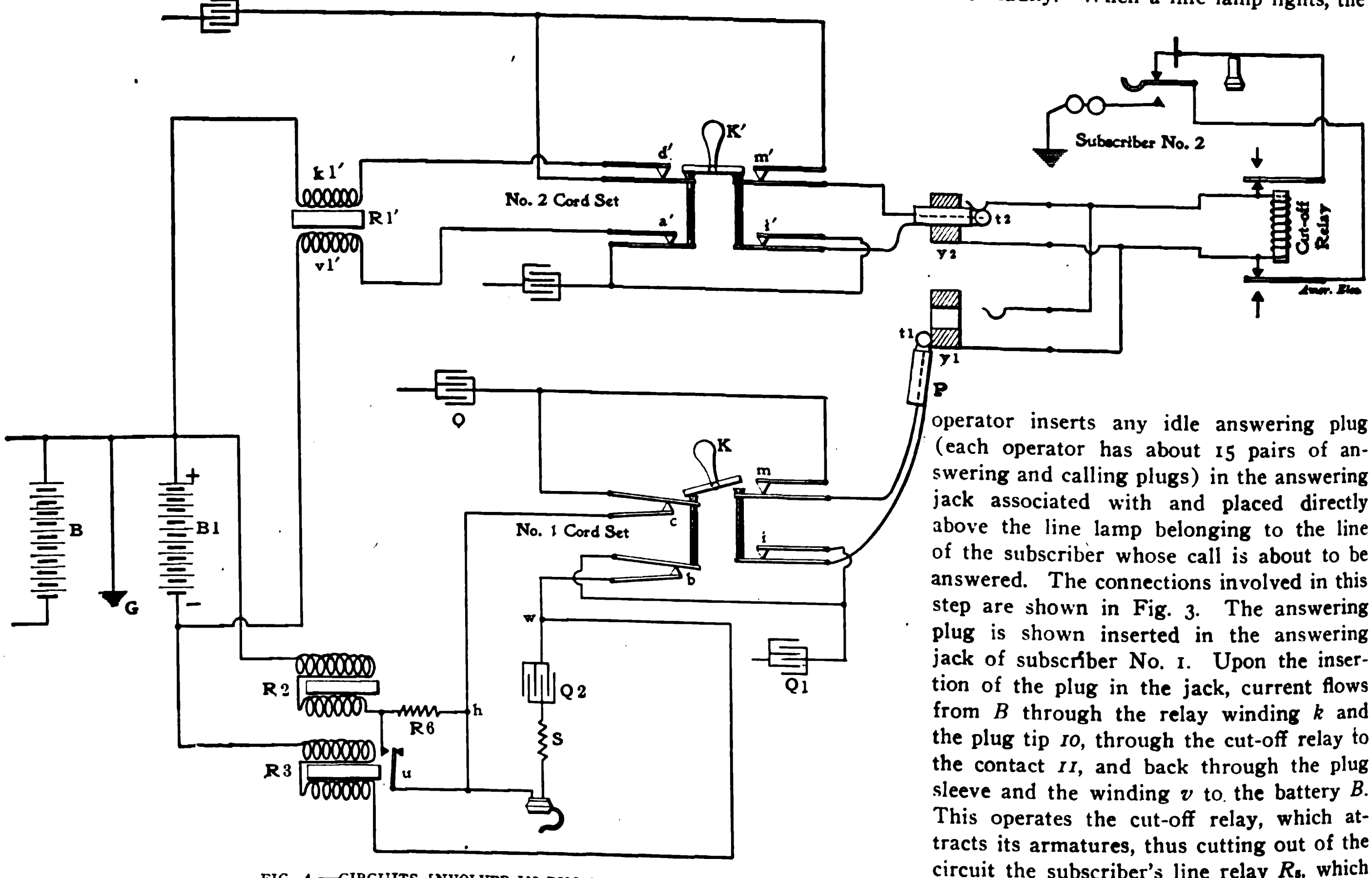

FIG. 4.—CIRCUITS INVOLVED IN BUSY TEST.

One operator's cord circuit is shown in Fig. 2. The supervisory relays, *R* and R_1, have two windings each, each winding having a resistance of 10 ohms.' The coils are so wound that when current flows from the battery through both of them their magnetizing actions neutralize each other, and the relay remains unoperated as though no current were passing. However, if current flows through only one coil, or if a sufficiently larger current flows through one than through the other, then the relay attracts its armature. Two tubular relays, R_2 and R_3, are used in order to give both sides of the circuit the same resistance and inductance, the relay R_2, not doing any work. The relay R_3 short-circuits the resistance coil R_6, which is about 700 ohms. The Morse relay *M* controls the supervisory lamp L_6. There is one such relay and supervisory lamp for each operator's position. The lamp requires about ¼ ampere to give a 3-c.p. light. The Morse relay M_1 (of 1 ohm resistance), in series with L_6, controls the supervisory buzzer *F*. There is only one of these relays and one supervisory buzzer for the entire exchange. The Morse relay M_1 can be energized by any one of the position relays, *M*. As will be apparent later, the supervisory pilot lamp L_6 will light every time any calling subscriber in that operator's position hangs up his receiver, and remain lighted until the operator removes the plug from the jack. This enables the monitor to see whether the operator is clearing out her line circuits properly. *D* is the ringing dynamo and *I* a retardation coil of about 80 ohms resistance, the function of which will be shown later. The third coil, *o*, in the operator's induction coil is connected to the chief operator's desk, thereby enabling the chief operator to listen in whenever she desires and without the knowledge of the operator.

It now remains to show the connections involved when the operator answers the call received, when she determines whether the subscriber's line desired is in use, and if not in use how the called-for subscriber's bell is rung and the calling and called-for subscribers are put into communication. Fig. 2 shows the operator's cord circuit complete, but in the subsequent figures only such connections as are involved in each step will be shown, in order to follow out the operation of the various circuits more readily. When a line lamp lights, the operator inserts any idle answering plug (each operator has about 15 pairs of answering and calling plugs) in the answering jack associated with and placed directly above the line lamp belonging to the line of the subscriber whose call is about to be answered. The connections involved in this step are shown in Fig. 3. The answering plug is shown inserted in the answering jack of subscriber No. 1. Upon the insertion of the plug in the jack, current flows from *B* through the relay winding *k* and the plug tip *10*, through the cut-off relay to the contact *11*, and back through the plug sleeve and the winding *v* to the battery *B*. This operates the cut-off relay, which attracts its armatures, thus cutting out of the circuit the subscriber's line relay R_5, which is connected to contact point *8*, as shown in Fig. 1. The line relay, being cut off at *8*, is de-energized, and hence the line lamp goes out, the circuit of the latter being opened at contact *2*, Fig. 1.

The current that flows through the coils *k* and *v* does not energize the supervisory relay R because it flows through the two coils in opposite directions around the iron core, and since the number of turns and the current in each coil are exactly equal in this case the relay is not magnetized at all. This is essential because otherwise the supervisory lamp (L, Fig. 2) would light when it should not. Immediately upon the insertion of the plug in the jack, the operator throws her combination key K to the listening side, as shown in Fig. 3. The operator's receiver, secondary coil s, and condenser Q_2, which are in series, are now connected through contacts c and b in the listening key, condensers Q and Q_1, and the plug and jack contacts to the subscriber's line wires. Therefore, the operator and subscriber can now converse with one another. The cut-off relay is in shunt to the talking circuit, but it is a tubular relay and of rather high resistance, hence it has a very high impedance for the rapidly fluctuating talking current. Consequently it impairs the talking efficiency of the circuit but little.

It is evident that the battery B supplies the subscriber's transmitter with current and that the operator's transmitter and primary winding p of the induction coil are in a local circuit which is supplied with current by the battery B_1. The two batteries B and B_1 are exactly similar. They are storage batteries, each set having ten cells so as to give about 20 to 22 volts when charged. One battery supplies each side of the cord circuit, and examination of the circuits will make it clear that when two subscribers are talking together each transmitter receives current from a separate battery; although, of course, one-half of all the subscribers talking at any one time have their transmitters supplied with current from one battery and the other half from the other battery.

When the operator receives from the calling subscriber the number of the subscriber with whom connection is desired, she takes up the calling plug, or as some prefer to call it, the connecting plug, of that cord circuit and makes the "busy" test, to determine if the line of the subscriber called for is already in use; that is, busy. The operator determines whether the line is in use, without disturbing the conversation if it happens to be in use, by touching the tip of the calling plug to the sleeve contact of the jack belonging to the line of the subscriber desired. If the line is in use she hears a click in her receiver as she touches the tip of the plug to the sleeve of the jack; if the line is not in use she gets no click. The circuits involved in this busy test are shown in Fig. 4, in which t_1 is the tip of the calling plug, as before, and y_2 a jack at another section of the multiple board where the operator making the busy test cannot see it. Cord set No. 2 is in use connecting subscriber No. 2 to a third subscriber. Only those parts of the two cord circuits involved in the busy test are shown. The sleeve contact of the calling plug, P, is open so that no current can flow from B_1 through R_8. Before the tip t_1 is touched to the jack of the busy line, the point h has the potential of $+ B_1$ because no current flows through R_2. Hence the difference of potential from h to w is equal to that at the battery terminals. There being no current through R_8, the armature u rests against its backstop. As soon as t_1 touches the jack current flows from $+ B_1$ through R_2, R_6, h, c, m, t_1, y_2, i', a', v_1', to $- B_1$. This current flowing through R_2 and R_6 produces sufficient drop in the actual potential of the point h, so that the difference of potential from h to w is considerably less than it was, and consequently the e.m.f. impressed on the condenser Q_2 is suddenly decreased, and a positive discharge suddenly flows from Q_2 through s and the operator's receiver to h, as the potential of h falls, thereby producing a click in the operator's receiver. The resistance R_6 is used to prevent too loud a click in the operator's receiver. If the line desired is not busy, no click will be produced in the operator's receiver when the tip t_1 is touched to the jack, because no current can flow in either the sleeve or tip side of the calling cord circuit for the reason that both are open at the jacks y_1, y_2, etc.

If the operator hears no click in her receiver, she inserts the plug in the jack and then closes her key K to the right, thereby establishing the connections shown in Fig. 5. Current now flows from $+ B_1$ to G, through ground, G_2, D, lamp L_4, f, jack, cut-off relay, plug tip, spring e, and retardation coil, to $- B_1$. Enough current flows to energize the cut-off relay and cause it to connect the jack to the subscriber's line circuit in order that a ringing current may be sent through to the subscriber's bell. It may seem odd to send a battery current through the alternating-current ringing generator, but this is necessary with the wiring here used in order to be able to ring the subscriber's bell. The alternating current from the ringing generator flows through L_4, contact f, plug and jack sleeve, armature z, bell, G_4, earth, and G_2, back to the generator. There is but little loss of the ringing current through the cut-off relay, retardation coil, battery and ground path, because of the high impedance offered by the retardation coil and cut-off relay to the alternating ringing current.

When the operator releases the ringing key direct current flows through the cut-off relay from $+ B_1$ through k_1, d, m, plug tip, cut-off relay, jack sleeve contact, i, a, and v_1, to $- B_1$. This current flowing through the two coils k_1 and v_1 of the supervisory relay R_1 in opposite directions around the core, would not magnetize the core, but there is also another path open for the current until the subscriber removes his receiver from the hook. This path may be traced from $+ B_1$, through G, the earth, G_4, bell, hook-switch, armature z, jack and plug, i, a, and v_1 to $- B$. Sufficient extra current flows through this path, which includes the winding v_1, to energize the relay R_1; hence the supervisory connecting lamp L_1 lights and remains lighted until the subscriber removes his receiver from the hook. By this means the operator knows whether the called subscriber answers his telephone.

As soon as the called subscriber takes his receiver from the hook, his ground connection is broken and the currents through the two coils k_1 and v_1 become equal; the relay R_1 is no longer energized and the supervisory lamp L_1 goes out. The two subscribers can now converse. One subscriber's transmitter is supplied with current from B and the other from B_1, and these batteries also keep the cut-off relays energized through circuits that the reader will readily be able to trace out for himself. The talking currents pass from the answering jack to the calling jack through the condensers Q and Q_1 in the cord circuit shown in Figs. 2 and 3, which condensers therefore shunt the talking currents around relays in the cord circuit.

When the conversation is finished, the hanging up of each receiver will cause the corresponding supervisory lamps L and L_1 (see Fig. 2) to light. This is due to the ground connection made at the subscriber's telephone, thereby allowing more current to flow through one winding of the supervisory relay than through the other. For instance, when a sufficiently larger current flows through the winding v_1 (see Fig. 2) than through k_1 of the supervisory relay R_1, then the latter draws up its armature and current flows from $+ B_1$ through the connecting, or calling, supervisory lamp, L_1, armature and core of relay R_1 back to $- B_1$. The lighting of this supervisory lamp L_1 notifies the operator that the called subscriber has hung up his receiver. Similarly the lighting of the answering supervisory lamp L notifies the operator that the original calling subscriber has hung up his receiver. When both supervisory lamps are lighted the operator knows that both subscribers have finished using the circuit and she withdraws both plugs from the jacks. If one lamp remains lighted the operator un-

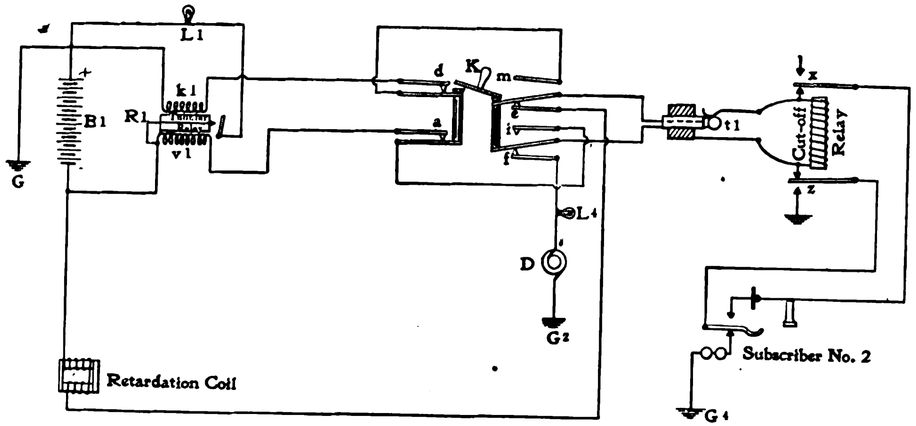

FIG. 5.—CONNECTIONS FOR CALLING UP SUBSCRIBER.

derstands that the corresponding subscriber wants another connection, and she withdraws the other plug and listens in on the plug remaining in the jack to find out the new connection desired.

In Fig. 2 it will be seen that the Morse relay *M* will be energized whenever the supervisory lamp *L* is lighted because the two are in series. Consequently, the supervisory pilot lamp L_8 will light whenever any supervisory lamp on the answering side of any cord circuit at one operator's position lights. All the supervisory lamp circuits on the answering side of all the cords at one operator's position are joined together at *S*, from which point they have a common return path through the Morse relay *M* to the negative terminal of B_1. Furthermore, the Morse relay M_1, is energized whenever any supervisory pilot lamp at any position on the board is lighted, because all supervisory pilot lamp circuits are joined together at *S'* and from there have a common return path through M_1 to the ground and to $+B_1$. As the buzzer *F* would be ringing all the time through the day, it is cut out by means of the switch.

If the operator finds it necessary to listen on the circuit while two subscribers' lines are connected together, she must be able to do so without disturbing them in case they should be talking and everything is all right. Provision is made for this in the circuits shown in Figs. 2 and 4. Suppose two subscribers' telephones are properly connected by the cord circuit shown in Fig. 2. To listen in, the operator draws forward her listening key *K;* this act disconnects both windings k_1 and v_1 of the relay R_1 from the circuit, and the cut-off relay (see Fig. 4) would be without current were it not for the fact that the same act connects this cut-off relay to the battery B_1 through the relays R_3 and R_8. Thus R_3 and R_8 are substituted in place of k_1 and v_1 and the subscribers are not apt to notice that the operator has tapped her receiver across the circuit.

Suppose in Fig. 4 that plug *P* is in the jack and the plug above removed. Current can now flow from $+B_1$ through R_2, *u* (because R_8 is closed, as will be seen in a moment), *h*, *c*, *m*, t_1, cut-off relay, y_1, *i*, *b*, *w*, and R_8 to $-B_1$. Sufficient current flows through R_8 to attract the armature and so short-circuit the 700 ohms in R_6. Thus, there is an equal amount of resistance and inductance, the same as before the listening key was closed, between each terminal of the battery B_1 and the called subscriber's line wires. It will also be evident that the condensers *Q* and Q_1 still connect the calling and called subscribers' lines together, and that the operator's receiver and the secondary winding of her induction coil are bridged across the called subscriber's line circuit, so that she can talk to and hear either subscriber.

In this system the jacks are very simple and require but little switchboard wire, as compared with systems having jacks with three contacts. Moreover, there are no relays or other coils directly in the talking circuit. However, there are two condensers in the talking circuit, and the cord circuit is not very simple, to say the least. The calling subscriber receives some very disagreeable clicks in his receiver while the operator makes the necessary connections. Since the ground is normally connected through the subscriber's bell to one line, it is absolutely necessary to have an efficient lightning arrester and small current protector at each subscriber's instrument in order to prevent frequent damage to ringer coils.

Lessons in Practical Electricity

THE INCANDESCENT LAMP.

The "incandescent" or filament type of electric lamp is a remarkably simple piece of apparatus—probably the simplest of the entire list of what might be termed the principal electrical devices. The lamp proper consists of an entirely closed glass bulb, a filament of carbon inside the bulb and two terminals on the outside, to which the filament is connected by "leading-in" wires of platinum which pass through the glass, the latter being sealed around the wires. The commercial form of lamp is undoubtedly familiar to every reader of this paper, and does not require illustration. The behavior of the lamp is as simple as its construction; the filament or thread of carbon gives out light when the proper current is passed through it merely because its resistance is such that the current raises its temperature to white heat; hence the name "incandescent."

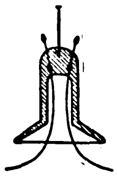

FIG. I.

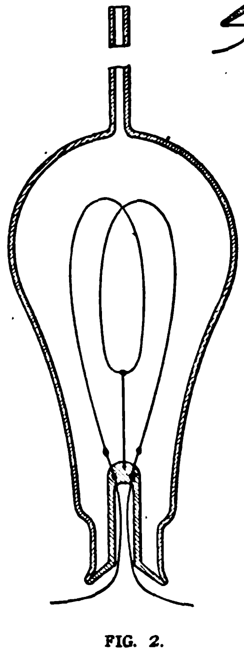

FIG. 2.

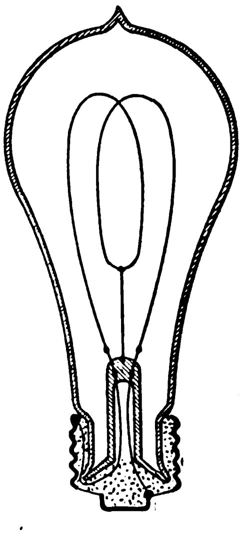

FIG. 3.

The carbon filament in probably all of the present incandescent lamps is made of cellulose, which is a gelatinous solution of cotton in (usually) chloride of zinc. This is squirted through a fine nozzle into a tank of alcohol, and the alcohol causes it to harden to about the consistency of cooked spaghetti or vermicelli. After being dried it is cut into suitable lengths for filaments and carbonized; the filaments are then treated to a "flashing" process which deposits carbon on each filament at all points where the cross-section is smaller than the largest initial section of the filament, after which each filament is "mounted" on a pair of leading-in wires, which have been previously "sealed" into a stump of glass (Fig. 1) that ultimately becomes the enclosing part for the "neck" of the bulb. The relation which the "mount" shown in Fig. 1 bears to the complete lamp is clearly indicated in Fig. 2, which represents a transverse section through the bulb of an "anchored filament" lamp ready to have the air drawn out. This is done through the small tubular extension at the upper or "tip" end of the bulb, and the tube is then "sealed off" close to the bulb, leaving a small pointed tip (from which that end of the bulb takes its name) on the outside and an almost perfect vacuum in the bulb.

The reason for withdrawing the air from the bulb is that if the filament were heated in air, the oxygen of the air would combine with the carbon, causing the combustion, and consequent destruction, of the filament—in other words, the filament would merely burn up, as it is commonly but inaccurately expressed. Even enclosed as it is and located in a vacuum, the filament is slowly destroyed by the intense heat at which it is worked. Another important advantage obtained by putting the filament in a vacuum is that there is no heat-conducting medium between the filament and the bulb, practically all the heat that is emitted being that which radiates from the filament (a small amount is lost by conduction through the leading-in wires). If there were any gas or vapor within the bulb it would conduct additional heat to the glass walls, and also dissipate heat by convection, so that with a given current in a given filament, the temperature of the filament would be reduced, and consequently less light would be obtained. This explains why the temperature of an ordinary incandescent lamp bulb is only about 150 degs., while that of the filament is about 2800 degs. The destruction of the filament referred to above is not due to combustion, because, as just explained, there is no oxygen left in the bulb. There is a disintegration of the filament by some process that has never been positively identified or explained, the result being that impalpable particles of carbon are deposited on the bulb, causing a gradual darkening of the glass that is readily discernible.

The leading-in wires are made of platinum because that metal has the same coefficient of expansion by heat as that of glass. If the leading-in wires had a higher coefficient they would expand more than the glass when heated and crack it, letting in air; on the other hand, if the wire had a lower coefficient than the glass, the latter would expand more than the wire and air would leak in around the wires. In either case, the air admitted to the bulb would cause the combustion of the filament immediately.

As explained in an early Lesson, almost every conductor of electricity will increase in resistance if its temperature is increased. Carbon is an exception to the rule. Its resistance *decreases* very rapidly with an increase in temperature, up to the point where it begins to turn red under the influence of the heat produced by the current; from this point until it is white hot, the resistance decreases more slowly. The ordinary filament when at its "working" temperature has about one-half the resistance that it has when cold. The standard filament is one that gives out a mean illumination of 16 "candle-power" at right angles with the axis of the lamp from base to tip, the unit of intensity being derived from a very reliable spirit lamp. The power required to bring a 16-c.p. filament up to normal intensity varies from 50 watts to 64 watts, according to the temperature at which the filament is "worked." The higher the temperature, the higher will be the efficiency in light per watt, but the shorter will be the life of the filament. But for this latter fact, the efficiencies now obtained might be very greatly increased, of course. A lamp of any given candle-power may be made to give a much greater illumination by the simple expedient of increasing the current passed through the filament—and thereby hastening its destruction—and the increase in candle-power is greater than the increase in electrical power. The accompanying table shows roughly this relation between voltage, watts and candle-power for 16-c.p. filaments requiring normally 3.1 and 3½ watts per "candle" respectively, and intended to be worked at 100 volts; the figures relating to the 3.1-watt lamp being given in the columns marked *A* and those for the 3½-watt lamp under *B*.

Effect of Insufficient and Excessive Voltages upon the Candle-power, Wattage and Life of an Incandescent Lamp Filament.

Volts at Terminals.	Candle Power.	Watts.		Per cent. of Normal Life.	
		A.	B.	A.	B.
96	12.6	45.5	51.7	220	247
97	13.4	46.5	52.7	179	195
98	14.2	47.5	53.8	146	153
99	15.1	48.5	54.9	121	126
100	16	49.6	56	100	100
101	16.95	50.7	57.2	82	84
102	17.9	51.7	58.4	68	70
103	18.9	52.7	59.5	56	58
104	19.85	53.6	60.5	45	47
105	20.8	54.5	61.4	37	39

The table shows, for example, that a 3.1-watt lamp when subjected to 5 per cent excess voltage gives 25 per cent more candle-power and only requires 10 per cent more electrical power, but its life is shortened 63 per cent. The reason a 5 per cent increase in voltage produces a 10 per cent increase in watts is that the resistance of the filament decreases, as already mentioned, with the increase in temperature. Fortunately the temperature does not increase directly with the current and the resistance does not decrease in proportion to the increase in temperature; if they did, there would be no carbon filament lamp.

Letters on Practical Subjects

A Home-Made Testing Set.

To the Editor, American Electrician:

The accompanying drawings represent a simple portable testing set to be made and used by the man who has charge of a small plant and whose employer does not consider it essential to have any testing instruments as part of the equipment. I presume I am not the only one of your readers so situated.

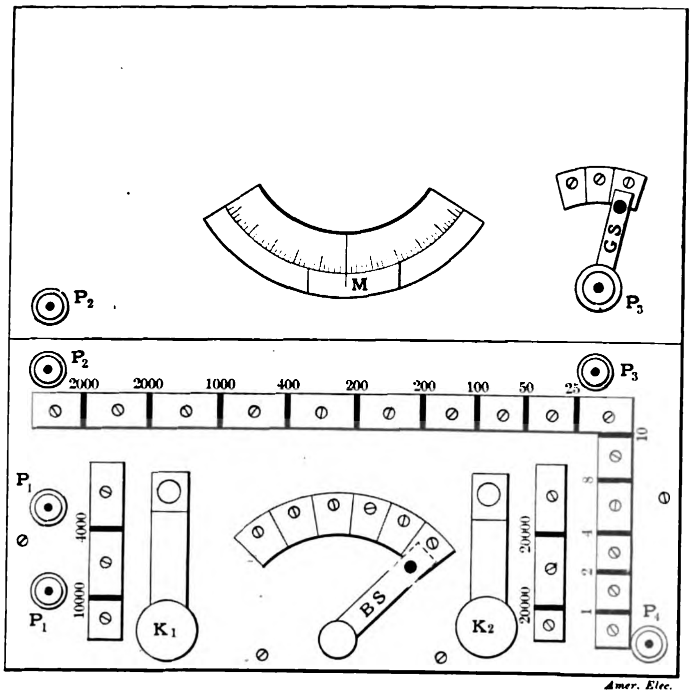

FIG. 1.—HOME-MADE TESTING SET.

Anyone with the few necessary tools and a little mechanical skill can make this set. The number of uses to which it can be applied is limited only by the user's knowledge of the fundamental electrical laws. If he studies the Lessons in the AMERICAN ELECTRICIAN he will be in possession of the required knowledge. (Incidentally, I may say that I have found these lessons of more benefit in my work than the course I took in a correspondence school; they appeal to the man who handles the machinery.)

I have limited the drawings to the connections and the essential electrical parts of the set, and these can be modified to suit various cases, depending upon the taste and mechanical skill of the individual maker. The first thing required is a suitable box 10½ ins. x 10½ ins. x 5 ins., made out of ½-in. stuff and solidly built. It should have two cleats on the inside 1½ ins. from the top, to support the shelves or false bottoms on the under sides of which are mounted the resistance coils and the galvanometer. The outside can be finished as desired; my own is finished with lampblack and shellac. The shelf on which the resistance coils and their connecting blocks are mounted should be of hard rubber 9½ ins. x 4¾ ins. The brass blocks for short-circuiting the coils can be from ⅛ to 3-16 in. thick and about ½ in. wide; their length will depend upon the number of coils one decides to use. For plugs, stiff and springy copper or brass strip about 1-32 in. thick and bent to shape as shown in Fig. 3, may be used. It should be spread enough to require some compression to force it between two blocks, so as to insure a good low-resistance contact. The coils may be of German-silver, ranging in size from No. 30 B. & S. gauge for the lower resistances to No. 36 for the higher. The bobbins on which they are wound should not be over 1¼ ins. long in order to leave room in the bottom of the box for the small dry batteries, which are 1¾ ins. x 4 ins. in height.

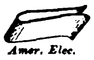

FIG. 3.

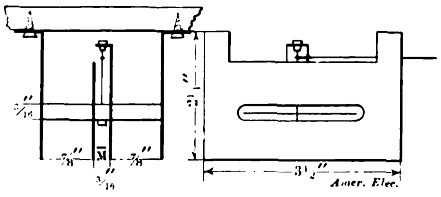

FIG. 2.—GALVANOMETER.

Fig. 6 shows how the coils are mounted and connected. The screws supporting the coils and those holding the brass blocks should be of brass, and the latter must be soldered into the blocks. For a standard coil, one can consult a wire table and select a size, say about No. 20, and carefully measure the required length for one ohm, which will be about 95 ft. in this case. With this as a standard and a slide wire bridge with a sensitive reflecting galvanometer, the other coils can be built up. Of course, they will not be very accurately adjusted, but they will answer for the purpose of the rough measurements and comparison for which the set is intended.

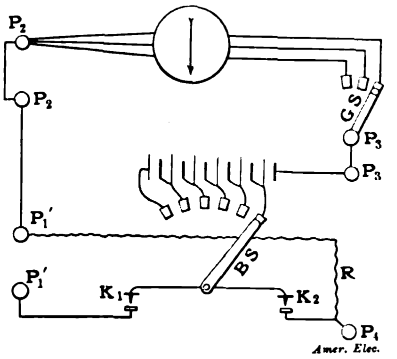

FIG. 4.—GALVANOMETER CONNECTIONS.

The two keys and the switches for battery and galvanometer can be made as shown in the drawing. Fig. 2 shows the form on which the galvanometer coils are wound and the method of mounting the needle and index. This form can be made of stout zinc or copper and must be thoroughly insulated in the coil space. The pivots out of an old alarm clock will answer very well for the galvanometer and a piece of the main-spring will make the needle and control magnet, which is indicated at *M* in Fig. 2. For an index arm or pointer a piece of the outer portion of cane will do very well. The whole moving part should be as light as possible, and the points on which it turns hard and very sharp.

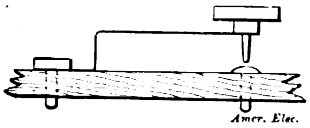

FIG. 5.—KEY.

There are three windings. First wind 500 ohms of No. 36 wire in each space and then add 200 ohms of No. 33 to each of these; this will give one set of coils of 1,400 ohms resistance. Then wind 5 ohms of No. 27 in each space and over this 1 ohm of No. 27. These windings should be so connected that with the galvanometer switch in the first position the two 1-ohm coils will be in circuit in series, in the second position, the two 5-ohm cells added to this, making 12 ohms; and in the third position the 1,400 ohms brought into series with the 12 ohms. In the last position the galvanometer should show a deflection of one scale division with one cell of battery, through about 100,000 ohms. A piece of mirror should be mounted under the scale for the first 20 degrees on each side of zero to insure correct reading.

Fig. 4 shows the connections. The substitution method of testing is used, as it is more rapid than the bridge method and probably more accurate with the style of galvanometer and the uncertain coils used. In the diagrams, P_1, P_2, P_3 and P_4 are binding posts. To use the set for measuring resistance, the unknown resistance is connected to P_1, P_1, suitable battery power and galvanometer resistance chosen, and K_1 is pressed; by changing the battery or the galvanometer switch one can get almost any deflection desired. Then release K_1 and press K_2, and by adjusting the resistance in the rheostat get the same deflection. To test the condition of a primary or secondary cell, connect it to P_2 and P_3 and take the deflection of the galvanometer through the high resistance and the low; this will give a fair idea of the battery voltage and current. To measure the internal resistance of a cell, connect it to P_3 and P_2 and connect P_3 and P_4 by a stout wire; then set the galvanometer switch at the low-resistance coil and unplug enough resistance in the rheostat to get a deflection of ten degrees. Say it requires 8 ohms; the galvanometer resistance being 2 makes a total of 10 ohms; now unplug enough additional resistance to get a deflection of 5 degrees on the scale; suppose it takes 14 ohms, then the resistance of the cell is about 4 ohms. The reason for selecting ten scale divisions to start is that up to this point the deflections are about proportional to the current.

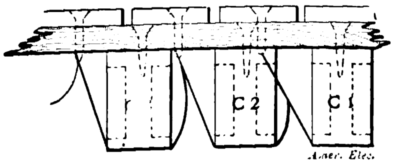

FIG. 6.—RESISTANCE COILS.

I have located crosses on our metallic telephone circuit within two to three hundred yards. On our high-tension circuits we are frequently troubled by boys throwing pieces of wire over the lines; these I can locate within a quarter of a mile. I have purposely omitted the full details of constructing each part, as it would require too much space, but I hope I have said enough to make it clear to anyone wishing to make this set. There is room enough in the bottom of the box for nine of the small size dry cells, five under the rheostat and four under the galvanometer. For all testing where a magneto bell is used, this set will be found more convenient and reliable.

Mesa, Ariz. FRANK W. CERNY.

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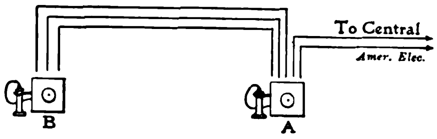
A Telephone Connection Problem.

To the Editor, American Electrician:

I submit herewith a problem in telephone circuits, which I would like very much to have someone solve for me. I have a line leading out from central to two generator call telephones whose talking circuits are in multiple. Each ringing circuit consists of one generator and bell as usual. A push-button is to be provided on each instrument.



PROBLEM IN TELEPHONE CONNECTION.

The problem is for *A* to be able to call central without disturbing *B*, and by pressing his push-button to be able to call *B* without disturbing central. The conditions at *B* are similar, that is, the user must be able to ring either *A* or central without disturbing the uncalled office. There will be three wires between *A* and *B*. No grounds are to be used on the line, and the connections at central are not to be disturbed. No battery current is to be used for calling. When central rings, only the bell at *A* is to respond. The push-buttons may be of any type. C. H. TEMPLE.

Los Angeles, Cal.

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Performance of Two-Phase Motors.

To the Editor, American Electrician:

In the article on integrating wattmeter connections published last month was included the following formula:

$$\left(\frac{Rev}{60} \times 40 \times 400 \times 1.2\right) \times 2$$

for calculating the horse-power of a two-phase motor from the revolutions of a meter disc. The actual example given was based on 20 revolutions, and 20 ÷ 60 × 40 × 400 × 1.2 × 2 was given as being equal to 6336 × 2 = 12,672, which, divided by 746, gave 17 horse-power. I would figure this to equal 6,400 × 2 = 12,800 watts, or 17.16 horse-power.

An objection to this method would arise from the fact that only one phase of the two-phase circuit is metered. It is well-known to those experienced in metering that no two-phase motor consumes the same energy on each phase, but that one phase will not only take less energy at times, but will at times even give reverse readings, especially when the motor is lightly loaded. In actual practice it is well known that two recording meters installed in series with two Weston indicating wattmeters would indicate forwards when the motor is started and until the load is reduced, when both the recording meters and Weston indicating wattmeters on one phase will read backwards. The writer has made numerous tests on two-phase induction motors, so that these statements are based on experience.

Philadelphia, Pa. J. B. SEAMAN.

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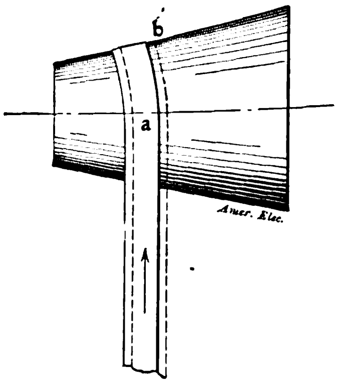
Belt Action on Pulleys Out of Line.

To the Editor, American Electrician:—

Referring to the note on this subject which appeared on page 121 of the March number, I take the liberty of correcting one part of the statement concerning the reason why a belt will run to the "tight" side of pulleys that are out of line with each other. The bicycle analogy does not apply.

Taking first the case of a slightly coned or tapered pulley (larger at one end than at the other), a belt running around it will tend to lie flat upon the conical surface, and on account of its latent stiffness will assume a position about as shown exaggeratedly by the solid lines in the accompanying sketch. If the belt travels in the direction of the arrow, the point *a* will, on account of the friction between the pulley and the belt, tend to adhere to the pulley, and will be carried to the point *b*, which is nearer the larger part of the cone than that previously occupied by the edge of the belt. The belt will then occupy the position shown by the dotted lines. This action will continue until the belt reaches the highest part of the cone, if it is not too tight to stretch that much. Consequently, if a pulley is made up of two equal cones placed base to base, the belt will try to climb to the high side of each, and therefore will run with its center line on the highest part of the crowning.



BELT ACTION ON PULLEY.

When pulleys are slightly out of line the belt will usually work toward the position in which it is tightest, and this may be explained in the same way as the tendency to climb in the case of a conical pulley. There is this difference, however, between the two cases. In the first case, the linear velocity of a point on the periphery near the large end of the pulley is greater than that of a point near the small end, which greatly assists the climbing: in the second case, the linear velocity is the same for all points on the periphery, so that the climbing is due solely to the action described.

In either case, if the angle between the surface of the pulley and the face of the belt as it would lie on a flat pulley in exact alignment is greater than the angle of friction, the belt will not adhere to the pulley at all, but will slide off at the loose side.

C. N. RUTHERFORD.

New York.

[The item in question was reprinted from an engineering periodical, but the customary accrediting was accidentally omitted. However, it is a fact that a belt will tend to run to the "tight" side of a crowned pulley *slightly* out of line, although the explanation given above is not accurate, nor is the one offered in the original note. We do not remember having seen an explanation that can be supported by mechanical theory, but we have many times proved by actual trial that a belt may run to the "tight" side of a dynamo or motor pulley when the machine is thrown a very little out of line with the driving shaft. The adjustment, in the observed cases, was a rather delicate one, a very slight additional departure from alignment serving to run the belt off the "near" edge of the pulley. Mr. Rutherford's explanation of the action of a belt on a coned pulley is correct.—EDITOR.]

Electrical Catechism

727. What is lightning?

Lightning is an electrical phenomenon occurring in the air between clouds and the earth or between clouds. It is generally a flash or spark passing between two clouds or between a cloud and the earth. The path is sometimes straight, but usually it follows irregular curves, somewhat zigzag in outline, and often forks in fantastic style. The flash is often oscillating, passing back and forth a number of times with exceeding rapidity. Sheet lightning is generally considered to be the reflection upon clouds of lightning at a distance, though it may consist of a large number of small flashes or of a brush discharge between neighboring clouds. Globe or ball lightning is a rare form in which a ball of fire moves slowly and quietly and then explodes violently.

728. What causes lightning?

We are ignorant of the ultimate cause of lightning, although much work has been done and many theories advanced to account for it. The immediate cause is the breaking down of the insulating qualities of the air between the earth and a charged cloud or between two clouds with unlike charges. The air or the vapor or dust carried by it is generally in a different electrical condition from the earth; when the particles collect into clouds their electrical condition becomes greatly different from that of the earth, the air between is subjected to a great strain, somewhat as though it were stretched or compressed; if the difference of potential between the cloud and the earth exceeds a certain amount, varying with the distance and the density and purity of the air, the air breaks down; the energy which had been stored in straining the air (or, what is the same, in charging the cloud), then takes the form of heat and raises the temperature of the air along the path of the breakdown to a high temperature, so that it becomes intensely incandescent and gives out the light characteristic of lightning. The irregularity of the path seems to be due to irregularities in the strength or purity of the air. The sudden equalization of the strain on the air is practically an electric current and it heats or even melts conductors in its path. The sudden and intense heating ruptures the cells of vegetable or animal matter which may be in its path; the air and moisture contained in masses may be heated and expanded so suddenly as to cause violent explosions that shatter the mass and scatter the parts widely.

729. What theories are commonly offered to explain the electrification of the clouds?

The general belief is that during the evaporation of water the vapor becomes electrically different from the remaining water; the invisible water vapor charges the air or contributes its mite to the electrification of any cloud of which it may become a part. The friction of the clouds among themselves or against hill and mountain tops causes a difference of electrical potential between the cloud and the earth. During snowstorms, the friction of the drifting snow against houses, trees, wires and other obstructions seems to be the cause of electrification, although this may be simply the occasion of transferring the charged condition from the snow to the wires and other objects. Having obtained an initial charge the differences of potential may be increased by the relative motion of clouds and earth in a similar way to the inductive actions in electrostatic machine, such as Wimshurst or Holtz. Measurements from high buildings and from kites show that the air is generally electrified. At the top of the Eiffel tower in Paris the air 1,000 feet above the earth shows a difference of potential from the earth sometimes as high as 10,000 volts on clear summer days.

730. What is the estimated power of a flash of lightning?

Lightning flashes vary greatly both in quantity and in length. Estimates of current strength and of the differences of potential are based upon a number of more or less uncertain assumptions. Measurements made in the mountains of France indicate occasional flashes amounting to 10,000 amperes. Estimates of potential differences run as high as 5,000,000,000 volts for a flash one mile long, an estimate probably much too high. Such estimates would indicate about 67,000,000,000,000 horse-power in a tremendous flash a mile long. The flash probably continues only a few millionths of a second, and the large horse-power represents a comparatively small amount of energy, say about 30 horse-power hours. Another estimate is that a cloud one mile high and one mile square charged to the breaking down point represents about 74,000 horse-power hours of energy. Such figures are at present simply interesting estimates.

731. What is thunder?

Thunder is a noise that follows a flash of lightning. It is generally believed to be caused by the sudden expansion of the air along the path of the discharge. Some scientists believe that the noise is caused by the condensation of the oxygen of the air into ozone by the influence of the electrical strain, which ozone then explodes and changes back to oxygen. The rolling sound comes from the repeated echoing against clouds or other masses. The fact that the "heat lightning" noticed along the horizon on summer evenings is not accompanied by thunder is accounted for by the fact that the light is reflected and travels further than the sound. The noise from "sheet lightning" is believed to be reflected upwards mostly and to be lost in the general confusion.

732. What is dark lightning?

Photographs of lightning sometimes show black streaks resembling the light streaks caused by lightning. These were formerly supposed to be caused by discharges which were not visible to the eye, but which acted chemically on the plates. Investigation showed, however, that photographic plates reverse under the action of excessive light, giving positives instead of negatives. The "dark lightning" is therefore simply a heavy discharge which reverses the chemical action on the plate.

733. How does lightning affect wires carrying electric currents?

Sometimes a lightning discharge strikes a pole or a wire in its tremendous dash to the earth, but such instances are comparatively rare. More commonly the wires are charged by electrostatic "influence" or are charged by electromagnetic induction, or by a combination of them. Sometimes the mere passing of a cloud will set up disturbances in lines when there is no evidence of lightning. The disturbances which cause most of the trouble come from electromotive forces set up by the discharge of lightning from the clouds to the earth, or between clouds.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

If there is a short circuit between two bars of a street-car motor commutator, will the armature burn out? S. W. S.

One coil of it will, and this will doubtless damage the coils alongside of it.

What is the difficulty in producing a satisfactory telephone repeater? G. M. J.

To produce a stronger impulse in the second circuit than the impulse received by the repeater from the first circuit.

What is the difference between a gasoline engine and a gas motor? (2) Is a kerosene engine as good as a gasoline engine for intermittent use? F. W.

There is practically no difference in the engines themselves. A gasoline engine is provided with a carburetor for gasifying the gasoline. (2) Yes.

What is the difference between a plating dynamo and an ordinary dynamo electric machine? E. C. D.

A plating dynamo is merely an ordinary direct-current machine of low voltage and capable of supplying a relatively large current. The usual voltage is from 8 to 10, and the current ranges from 100 to 10,000 amperes, according to the size of the machine.

How should an armature core having 33 slots be wound and connected, the number of coils to be 99? The field is four-pole. F. W. P.

Put on the coils so that each one embraces 7 teeth and connect the terminals of each coil to two commutator segments between which there are 48 other segments. In the usual armature winder's parlance this would be termed connecting the coils to "segments 1 and 50."

Why does the voltage of a shunt-wound dynamo increase when the resistance in the working circuit increases, the speed of the armature remaining constant? H. H. K.

Because the current is reduced and therefore the drop in the armature winding and brushes is reduced, leaving a larger proportion of the total internal e.m.f. available. The internal e.m.f. of the armature does not change appreciably.

Please give data for a six-inch spark coil? T. N. S.

Make the core 1⅛ in. in diameter and 12 ins. long. Use two layers of No. 12 wire for the primary winding, making the coil 11 ins. long, and make the secondary winding of 7 pounds of No. 36 double silk-covered wire. The core should be a bundle of No. 22 annealed iron wires.

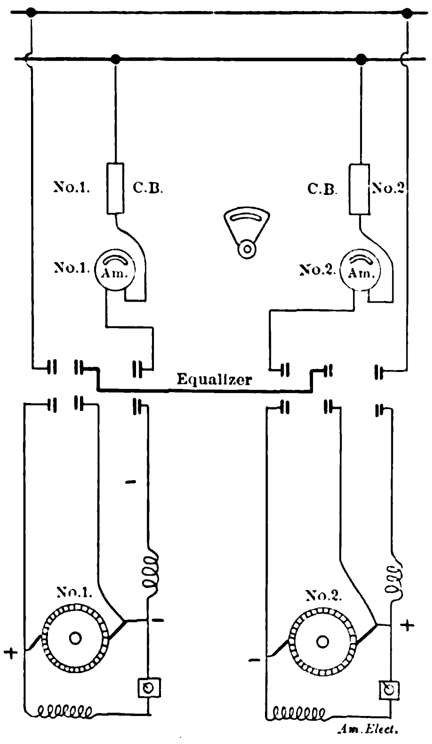
A four-pole 30-h.p. motor armature with 95 coils, after being rewound, was connected up with the terminals of each coil led to adjacent commutator segments, with the result that the armature runs about twice as fast as it did before being rewound. What is the trouble? J. M. D.

The original winding was evidently connected up wave fashion, with 46 commutator segments between the two to which the terminals of any one coil were connected. Since being rewound, you have connected it up lap fashion, so that there are only one-half as many coils in series in each armature path as there were before.

How is a solenoid motor-starter connected up for **controlling a motor driving an air pump, so that the motor begins to work when the pressure in the** storage tank falls below the proper point? J. F. R.

An electrical circuit-closer is controlled by the pressure in the tank so that when the pressure falls below the normal point the contacts close the circuit from some convenient source of electrical supply to the solenoid of the motor-starter, thus starting the motor. As soon as the pressure is restored to the normal value, the circuit-closer opens the circuit of the solenoid and stops the motor.

I am running two 500-volt dynamos in multiple, connected up as shown by the accompanying sketch. Machine No. 1 runs in the normal direction, but No. 2 has been reversed, which accounts for the difference in polarity. The machines do not seem to work well together; No. 2 carries more current than No. 1 after the two are thrown together, although the voltage is the same when they are separated. What is the trouble? L. G.



The ammeter of No. 1 machine does not indicate the total current that that machine is actually supplying; it only indicates the current passing through the series field winding. Put the ammeter in the positive lead of the dynamo, where it will indicate the total current supplied by the machine. The circuit-breaker should also be put in that lead; as it is now connected, it will not disconnect the dynamo from the bus-bars if it should open while the main switch of No. 2 machine is closed.

How is the wind pressure on a circular stack or chimney computed? (2) Is the atmospheric pressure against the back of the stack reduced by the suction of the wind passing on each side of the stack? A. S. D.

In practice, the pressure is computed by means of the formula, $0.57\ H\ D\ P =$ total pressure, in which H is the height of the stack in feet, D its diameter, and P the wind pressure per square foot as measured on a plane surface; the value of P is usually taken at 50 pounds per square foot. (2) There is a very slight decrease in atmospheric pressure on the back of the stack, but this is so small that it is negligible.

In a four-wire three-phase circuit, what causes a difference in voltage between different pairs of the three main wires, and the drop between any one of the main wires and the neutral wire? (2) In a monocyclic system, is the voltage between the two outside wires different from that between one of the outside wires and the middle or teazer wire, and if so, why? B. F. C.

Differences in the voltage between the different main wires are due to unbalancing of the load. We do not understand what you mean by the "drop" between the neutral and one of the main wires. The difference of potential between these two wires is that required by the load and is not a drop in the ordinary sense of that term. (2) The voltages are different because the main and teaser windings on the generator armature have different numbers of turns.

Why is the secondary winding of a wireless telegraph induction coil divided into sections? (2) Why are the different sections of different depths? (3) Why cannot double cotton-covered magnet wire be used with paper insulation between the layers? W. A. R.

In order to reduce the strain on the insulation, the maximum difference of potential of any one section of a four-section winding, for example, being about one-quarter of what it would be if the winding were continuous. (2) In order to grade the number of turns roughly according to the distribution of magnetic flux. (3) It can be used if a sufficiently heavy and high grade of paper be used over every layer of the winding, the paper being thoroughly varnished. It does not pay to use this construction because the paper takes so much room that the total number of turns within a given space is much less than can be obtained with the same degree of insulation when silk-covered wire is used.

What is meant in dynamo or motor specifications by the statement that "the temperature of the field winding is to be taken by the resistance method?" (2) What is considered good practice as to the maximum temperature to which cotton insulation on magnet wires should be subjected? (3) Why is a small motor, everything else being equal, so much less efficient than a large one? R. D. C.

This expression means that the rise of temperature in the field-magnet coils is to be determined by the increase in the resistance of the wire. The resistance of ordinary copper wire increases about .00225 ohm for each degree (Fahr.) of temperature increase, and the resistance method of measurement is usually preferred because it shows the average rise in temperature throughout the length of the wire of which the coil is made, whereas the thermometer measurement only shows the temperature at the point where the thermometer is applied. (2) 140 degrees Fahr. is a good practical figure, although magnet wires are frequently worked at higher temperatures. (3) They are not; it is precisely because everything else is not equal that the small machines are less efficient than the large ones. The efficiency of small machines is made lower than that of large ones in order to bring the cost of manufacture within reasonable limits: if all machines were given the same efficiency, there would be a comparatively small difference between the cost of a 10-h.p. motor, for example, and that of a 50-h.p. machine.

CONTROL SYSTEM FOR THE NEW YORK SUBWAY MOTORS.

The accompanying engraving is a diagram of the complete control and operating circuits for one motor car, of the type to be operated on the New York underground railway, and shows that the system is an elaboration of the series-parallel method used on ordinary surface cars. The controller drum and its "fingers" control actuating circuits of electromagnetic switches, known as "contactors," which in turn control the working or motor circuits. This is very similar to the system now in use on the Manhattan elevated trains, but there are several points of difference. One of these consists in the use of an attachment on the controller which provides automatic acceleration at a predetermined current without preventing or interfering with the manual operation of the controller at less than the predetermined current if desired. As arranged, the controller has 12 notches instead of 10, as in the case of the Manhattan controller. The operating cylinder instead of being directly attached to the controller handle is moved by the handle through the medium of a spring. The motorman may move the operating handle notch by notch, the operating cylinder following, or he may throw the handle to either the full series or the full parallel position. In either case, the spring causes the operating cylinder to follow the movement of the handle until it reaches a position corresponding to that of the operating handle; but the operating cylinder is prevented from moving too rapidly by a limiting device, which is controlled by the rate of current input through the medium of an electromagnetic relay in series with the motor circuit. This closes a local circuit, locking the controller cylinder against any forward movement until the acceleration current has fallen below the limit for which the relay is set; when this occurs, the relay releases the controller cylinder. Consequently, when the motorman "notches up" slowly, he controls the train in exactly the same manner as with the ordinary controller, but the automatic feature comes into operation when the rate at which the operating handle is turned would allow more than the desired amount of current to pass through the motors, if it was unlimited. In ordinary practice, however, the motorman is supposed to throw the handle to the full parallel position, and let the controller cylinder follow up, notch by notch, as fast as the relay permits.

An improvement has also been made in the form of contactor, and the method of mounting, two contactors being mounted on one base, instead of having them entirely separate, as in the Manhattan equipment. This plan of grouping contactors has been followed where two or more are of the same potential, and in the subway equipment there will be several groups of two and three contactors each. This saves room and also avoids the necessity of much of the interconnection of the contactors by heavy wires.

Referring to the diagram, it will be found by following out the control circuits that on the first notch the coils of contactors 6, 7, 9 and 15 are energized in the order given. This allows the main current from the motors to flow first through contactor No. 7, then through contactor No. 6, resistances R-1 to R-8, motor No. 1 and contactor No. 15; then through contactor No. 9 and resistances R-7 to R-12, and then through motor No. 2 to ground. On the second series notch, contactors No. 5 and No. 10 are picked up, each cutting out a portion of the resistance. The remaining resistance contactors pick up until all of the resistance is cut out, and the full series position is reached. The connections on the first parallel notch are such that the current for No. 1 motor passes through contactor No. 7 and No. 6, and through resistance R-1 to 8. The current for No. 2 motor in parallel working passes through contactors No. 8 and 9 and resistances R-7 to R-12.

It will be seen from this statement that the resistances are divided into two groups, and each group is always used with the same motor, and that each resistance contactor short-circuits one section of the resistance only instead of controlling in some cases more than one. With the new arrangement, therefore, each contactor carries the current of only one motor. At the same time the number of contactors required is not materially increased, owing to the fact that with the former method, in some cases, two contactors had to be used in parallel when working with heavy current. The total number of contactors is increased only from 14 to 16.

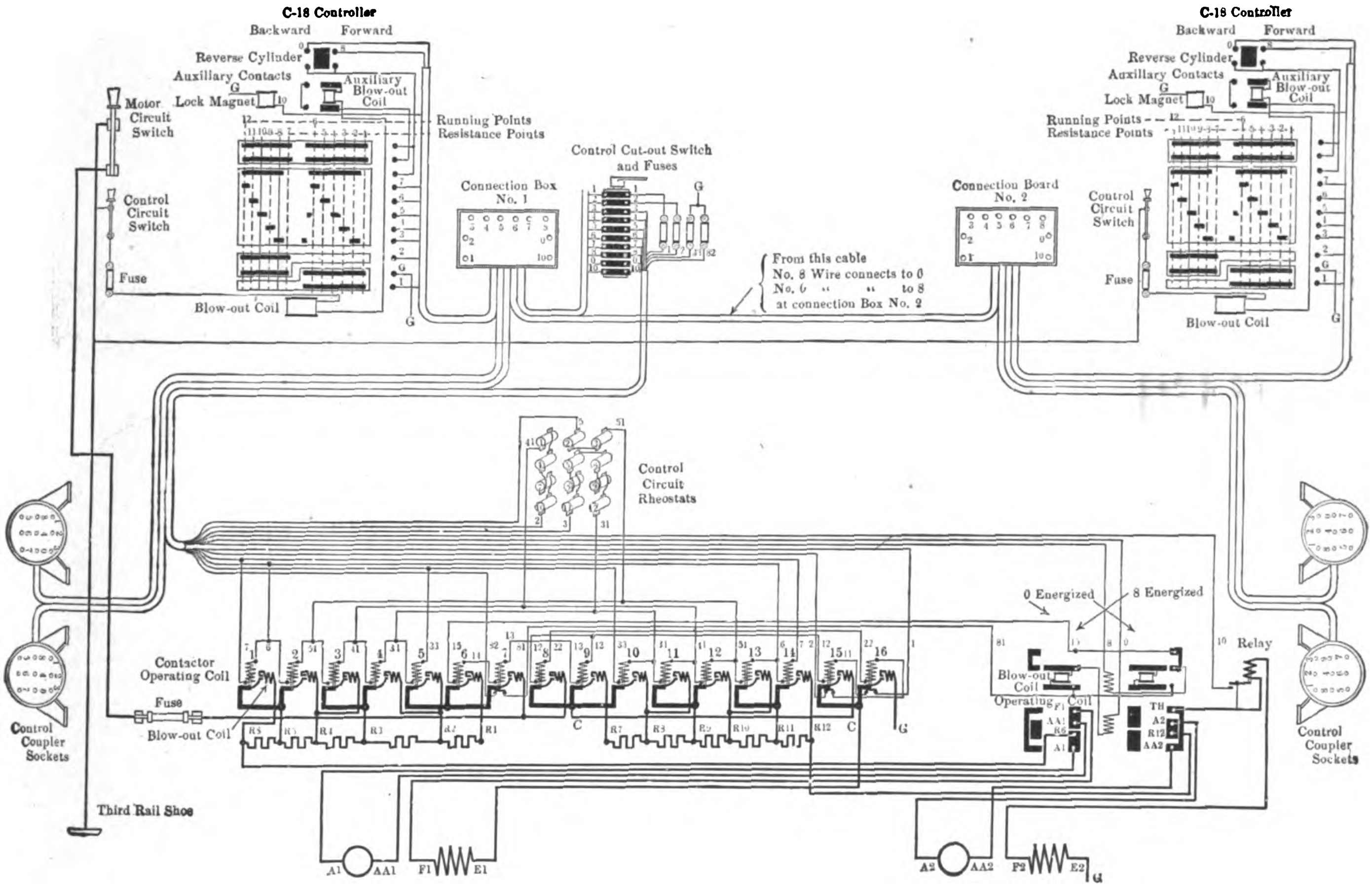

C-18 Controller
Backward
Forward
Reverse Cylinder
Auxiliary Contacts
Lock Magnet
Auxiliary Blow-out Coil
Motor Circuit Switch
Running Points
Resistance Points
Control Circuit Switch
Fuse
Blow-out Coil
Control Cut-out Switch and Fuses
Connection Box No. 1
From this cable No. 8 Wire connects to 0 No. 6 " " to 8 at connection Box No. 2
Connection Board No. 2
C-18 Controller
Backward
Forward
Reverse Cylinder
Auxiliary Contacts
Lock Magnet
Auxiliary Blow-out Coil
Running Points
Resistance Points
Control Circuit Switch
Fuse
Blow-out Coil
Control Circuit Rheostats
Contactor Operating Coil
Fuse
Blow-out Coil
Control Coupler Sockets
Third Rail Shoe
0 Energized
8 Energized
Relay
Blow-out Coil
Operating Coil
Control Coupler Sockets
A1
AA1
F1
E1
A2
AA2
F2
E2

FIG. 1.—DIAGRAM OF CONNECTIONS OF CONTROL SYSTEM FOR NEW YORK SUBWAY TRAINS.

New Apparatus and Appliances

CONDUIT FASTENER.

The Hart & Hegeman Manufacturing Company, of Hartford, Conn., has brought out a serviceable device in the shape of a conduit fastener. The conduit is first put through the outlet of the box and the fastener with very little effort is forced over the end; then by giving the conduit a slight pull the pointed teeth engage the fabric and hold it in place. This method of fastening conduit into boxes or wall cases will be recognized as a vast improvement over the older method of wrapping tape around the end of the conduit. Fig. 1 shows the device and Fig. 2 shows it applied to a conduit.

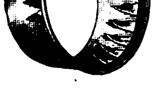


FIG. 1.

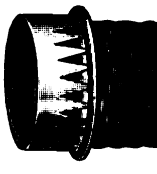
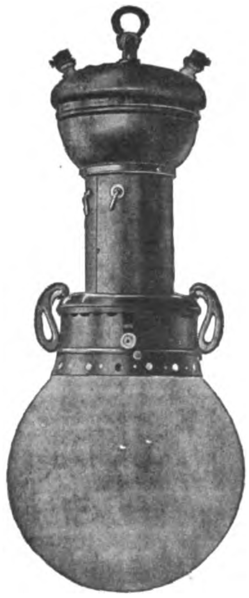


FIG. 2.

AN INTERCHANGEABLE ARC LAMP.

The Osborn-Morgan Company, Cleveland, Ohio, is building a constant-potential arc lamp that may be changed from a direct to an alternating-current circuit without changing any parts, a feature which will readily be appreciated by central station managers, since it necessitates the use of but one style of lamp for all circuits. As shown by the engraving—Fig. 3—the lamp is of the enclosed type and the case, which is said to be thoroughly weather proof, is made of sheet copper of sufficient thickness to insure stability and strength, so that the lamp may be used for outside as well as for inside work. The body of the case practically consists of two doors, which may be thrown open by turning a latch, thereby exposing to view the entire working mechanism and making all parts of the lamp accessible. The clutch is of the simple ring type and is applied directly to the carbon. The portion in contact with the carbon is of a special insulating material, insuring a steady clutch hold and freedom from arcing between the carbon and the clutch, and burning out the latter. Flexible cable is used to establish the circuit to the upper carbon, eliminating sliding contacts. The mechanism is controlled by a laminated horseshoe magnet in the head of the lamp, at a safe distance from the heat of the arc, which performs the functions of the customary reactance or choke coil of an alternating lamp and the feeding magnet, and serves as the feeding magnet only in the direct-current lamp. It is claimed that it works equally well under any variation of frequency between 16000 and 6000 alternations per minute. Between the poles of the magnet is the dash-pot and directly below this a laminated armature attached to the dash-pot plungers. The connection from the armature to the clutch contains a flexible asbestos tube, which prevents the vibrations due to the alternating current from reaching the clutch and thereby jarring the carbon loose. A double-throw switch mounted on the porcelain base changes the lamp from the alternating to the direct-current arrangement of circuits or cuts the current off entirely. The resistance wire is coiled around the porcelain base of the lamp, in the path of a current of air, as shown in Fig. 4, thus insuring good ventilation. It is removable without disturbing other portions of the lamp. The lamp is claimed to be economical in operation and noiseless on both alternating and direct-current circuits.



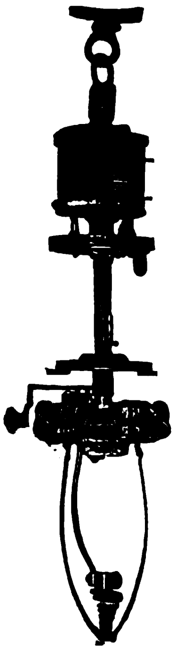


FIG. 3.—ARC LAMP.—FIG. 4.

NEW TELEPHONE TRANSMITTER.

Fig. 5 herewith illustrates a new type of telephone transmitter which in appearance and construction departs radically from the familiar "solid back" type of transmitter. This instrument is known as the "button" type transmitter, deriving its name from the "button," shown full size by Fig. 5. This "button" is entirely self-contained. The instrument carries within itself two sound diaphragms, a carbon chamber and two electrodes, and is designed to slip into the sound chamber carried at the end of the pivoted arm. Two cords are carried up through the inside of the arm to make the necessary electric connection. The "button" is not a permanent part of the sound chamber and may be removed and replaced by a new one at any time by removing the face plate and loosening the cord connections. In its construction the "button" consists of a carbon chamber and two vibratable electrodes carried by mica washers. These mica washers carrying the electrodes are clamped by steel rings to opposite sides of the carbon chamber, effectually sealing the same and making it moisture proof. Each electrode has clamped to it a sound diaphragm, which diaphragm has no other support. This allows freedom for the periphery to vibrate and is said to insure the tuning of the two diaphragms to the same characteristic note.

It also is claimed to permit of a permanent adjustment of the electrodes, inasmuch as the support of the carbon chamber and electrodes cannot be at variance with the support of the diaphragm.

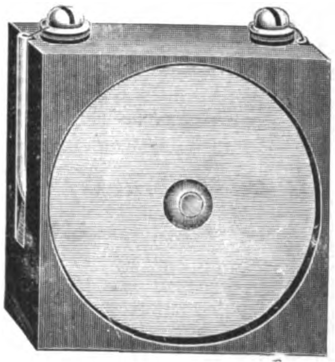


FIG. 5.—"BUTTON" TYPE TRANSMITTER.

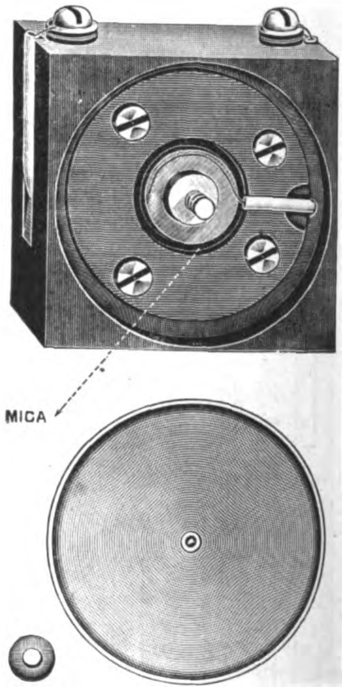


FIG. 6.—VIEW SHOWING WORKING PARTS OF TRANSMITTER.

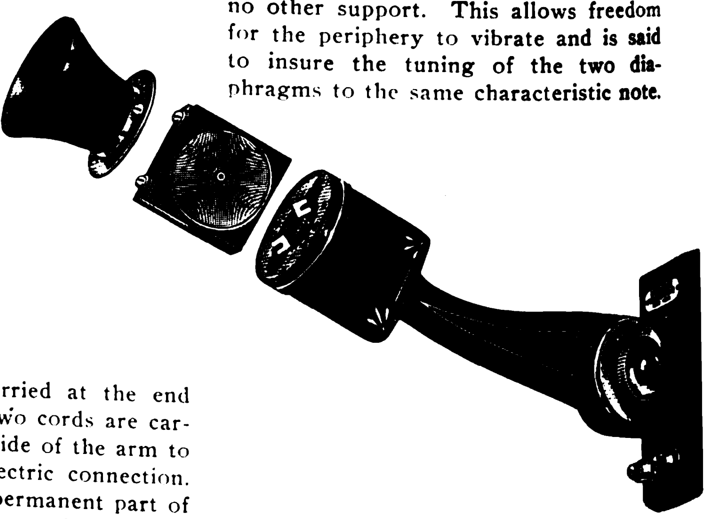


FIG. 7.—NEW TELEPHONE TRANSMITTER.

Means are taken to flexibly connect the periphery of the sound diaphragm to the "button" after it has been clamped in place on the electrode. This flexible connection prevents the sound waves from impinging on its under side. It is claimed that this method of supporting the sound diaphragm not only gives greater tone volume, but clearer and sharper articulation as well. It is for this reason that the size of the diaphragms can be so materially reduced from standard, as shown in the illustration, and the volume of tone produced still be considerable. When the "button" is in place within the sound chamber the surface of the diaphragms is transverse to the line of progress of the sound waves and the "button" presents to the opening at the mouthpiece only its edge. This effectually prevents any mechanical injury and removes the necessity of having a mouthpiece with a protective bottom. The sound waves on entering the mouthpiece are divided by the edge of the "button" and then impinging on the beveled sides of the sound chamber, are deflected against the diaphragms. The instrument is constructed throughout of a special hard non-corrosive alloy and each part is cast in a brass mould which insures accuracy and interchangeability of all parts while the non-corrosive feature of the alloy eliminates all liability of corrosion by the moisture of the breath. The finish is entirely of black enamel.

SECOR STANDARD OIL ENGINE.

Fig. 8 herewith shows a Secor standard oil engine, built by the General Power Company, of New York City, and direct-connected to a 15-kw. electric generator. The engine is of the single-cylinder, vertical, trunk type, resembling somewhat the open frame "marine type," used in stationary steam engine installations. This design is said to avoid excess material, and to combine a high factor of safety and durability with low cost of maintenance. The cylinder, which is water-jacketed, rests on columns of open-hearth steel, diagonally braced by steel tension rods. The frame combines maximum strength with minimum weight, and, although the cylinder and crank shaft are heavier than in the usual practice, the moderate weight of the engine bed, frame and fly-wheels is claimed to effect a marked reduction in the weight of the complete engine. The open frame permits ready access to the main bearings, crank pin and connecting rod. All journals are large in diameter and length, and special provision is made for copious lubrication. The cover for the cylinder and valve chest is made in a single casting, which, when removed, exposes the whole interior of the engine without disturbing any of the working mechanism. The shaft is balanced by crank counterweights, and the connecting rod is of the English high-speed marine type. Cam-operated poppet valves with spring closure are employed. The cam-shaft is actuated by a vertical lay-shaft, which is connected to the crank-shaft below and the cam-shaft above by helical gears. The governor is placed at the top of the lay-shaft, by which it is operated, the object being to permit close connection between the governor and the air and oil inlet valves. Speed regulation is accomplished by automatically varying the pressure of the working impulses so as to balance the engine load. The thermodynamic cycle adopted for these engines is that of Beau de Rochas. Electrical ignition of the hammer-break type is used. The mechanism for making and breaking the current to produce the spark is attached to the igniter plug, which is an easily removable plug inserted in the cylinder head. The battery, or sparking dynamo, is connected to a switch so arranged that the direction of the current through the igniting apparatus may be periodically reversed.

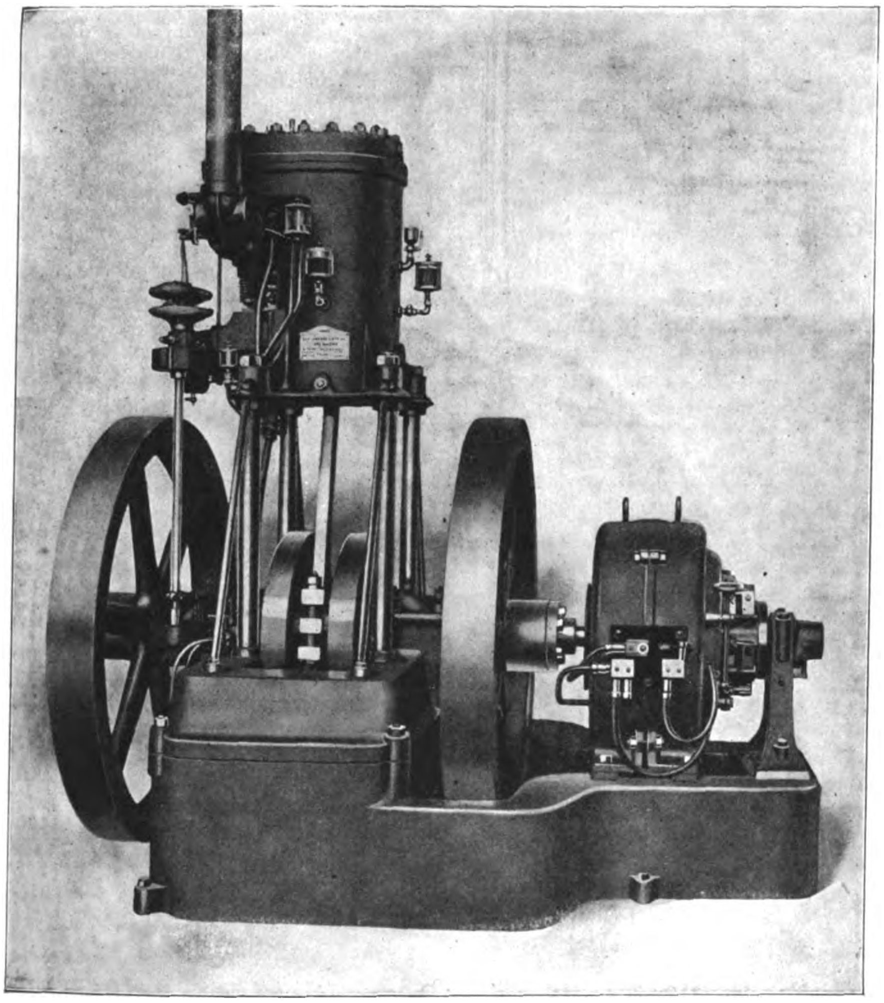


FIG. 8.—15-KW. SECOR OIL-ELECTRIC GENERATING UNIT.

WESTINGHOUSE MOTORS FOR RAPID TRANSIT SUBWAY.

Of the 680 motors required for the cars of the Interborough Rapid Transit Company, 340 are to be built by the General Electric Company and 340 by the Westinghouse Electric & Manufacturing Company; the motors built by the General Electric Company being described elsewhere in this issue.

The motors to be supplied by the Westinghouse Electric & Manufacturing Company were designed especially for this purpose, and were made to fit the particular conditions and requirements involved. One of these requirements, and perhaps the most difficult, was that of designing of a motor of large capacity to fit into a limited space. These motors, known as "No. 86," are of the heavy railway type, similar in general appearance to the well-known Westinghouse "50-C" motor. They will be supported on the truck by nose suspension. The normal capacity of the motor is 300 amperes at 570 volts, or 200 horse-power for one hour. With this current and voltage a tractive effort of 4,150 lbs. is developed at the periphery of a 33-in. wheel, at a speed of 19 miles per hour. Although designed for an average voltage of 570, the motor will operate satisfactorily with voltages up to 625. It will carry loads up to 500 amperes without injurious sparking.

The motor has a field frame of cast-steel, divided into halves on the line of the centers of armature and axle, and completely surrounding the axle. There are thus no separate axle-bearing caps, and the number of pieces is consequently reduced to the least number possible for an easily accessible motor. The two halves of the field are held together by eight bolts, and by removing these the top half of the field can be readily lifted off and access gained to the interior for inspection, repairs or the removal of the armature or field coils. When the top field is removed the lower half remains suspended from the axle by stirrups, which are permanently attached to the axle bearings.

The four-pole pieces are made of laminated steel punchings, held between heavy end plates and secured by rivets. Each pole piece is bolted to the field frame by three bolts. These bolts do not pass through the pole pieces but terminate in a long nut inside, thus affording a smooth, unbroken surface and rigid poles. The field coils are made of copper strap wound on edge. All four coils are exactly alike in form and in number of turns. The insulation between turns consists of asbestos and mica, held in place by shellac and baked at a high temperature under heavy pressure, so that the coil and insulation make a solid mass. The completed coil is sealed in a curved metal case, from which it is insulated by molded mica made like the V-rings of a commutator. This construction gives a coil which is fireproof, moisture proof and practically indestructible. Each coil is held in place by the metal case or shell, which is securely bolted to the frame.

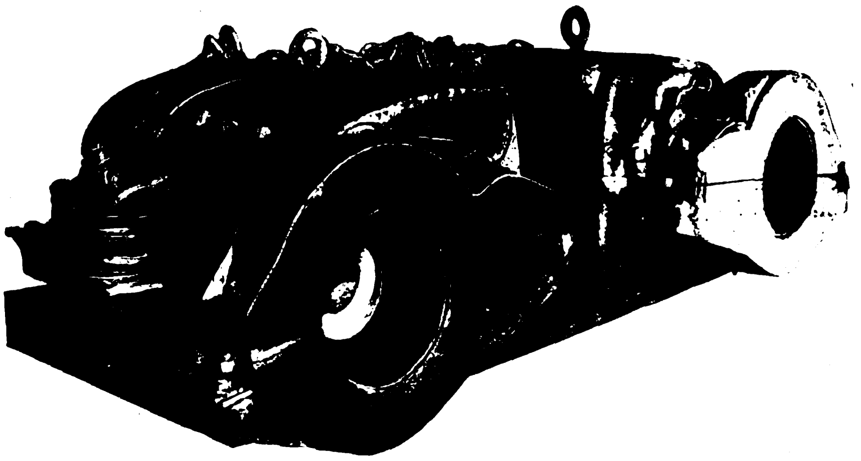


FIG. 9.—NO. 86 MOTORS COMPLETE, WITH BALDWIN-WESTINGHOUSE SUSPENSION.

The armature is 20 ins. in diameter and weighs 1930 lbs. It is of the slotted-drum type, and is composed of sheet steel punchings assembled on a cast-iron spider. The commutator is also carried on the same spider, and the shaft may thus be removed and replaced, should this ever become necessary, without disturbing the armature winding or its connection to the commutator. The winding is of the two-circuit-type, and is of ventilated construction. There are 53 slots and 159 coils, *i. e.*, three coils per slot. Each coil consists of a single turn of copper strap. The three coils which rest in each armature slot are formed and insulated before being put in place. They are placed in the slots without bending or hammering, and are carefully insulated from each other and from the core. Each conductor is continuous between commutator bars, thus giving minimum resistance and allowing the most effective insulation on all parts of the conductor. The armature insulation consists essentially of mica, which extends between turns at all points. The mica is protected by a sufficient amount of fibrous material to insure against deterioration, due to mechanical vibration. This fibrous material is treated with a moisture and oil-proof compound. An insulation is thus formed which has fireproof material between turns and between copper and iron at all points, and is, therefore, capable of withstanding very high temperature without injury.

The commutator is composed of 159 rolled and hard-drawn copper bars. These bars have solid necks raised above the surface of the commutator with milled slots, into which the armature bars are soldered. The bars are mounted on a cast-iron spider and held in place by two steel V-shape rings, one of which serves as an oil guard to protect the mica from oil or grease. A low voltage between the commutator bars is secured, decreasing the liability of flashing from any cause. The bars are insulated from each other by sheets of mica of a hardness that insures its wearing at the same rate as copper. The mica separating the bars from the rings is 1-16 in. thick. The wearing surface of the commutator is 16⅞ ins. in diameter and 9⅞ ins. long. The bars are of a depth which allows a reduction in diameter of 2 ins. The brush holders consist of two cast-brass arms, each secured independently to the commutator end of the upper frame casting by a special vulcabeston-headed bolt. The arms and bolts are insulated from the frame by fullerboard and mica bushings. Each arm carries three carbon brushes, ⅝-in. x 3-in. in sections. The brushes slide over finished surfaces and each is pressed on the commutator by a spring finger. The tension of these fingers is readily adjustable and the brush-holder arm is arranged for radial adjustment to allow for wear of the commutator. Copper clips are bolted to the carbon, and these clips are connected by flexible shunts, of ample capacity, to the body of the brush holder, thus relieving the springs from carrying the current. By this arrangement each brush holder can be easily removed through the opening above the commutator by loosening a single bolt.

Field and armature leads extend 5 ft. outside the motors, and are furnished with detachable connectors. The bottom field lead is brought out to the end of the lower field frame and carried up through a leader on the end of the upper field frame, avoiding necessity of disconnecting it when opening the motor. The completed motor will stand an insulation test between winding and motor frame of 4500 volts, alternating momentarily, or a test of 3000 volts for one minute.

The armature bearings are contained in housings, which are securely held between the halves of the field frame, being tongued and grooved to the frame and accurately boweled. At the pinion end the bearing is 4¼ ins. x 10 ins., and at the commutator end 4 ins. x 7 ins. These bearings are provided with drip grooves, into which oil is thrown by wiper rings on the shaft. The bearing boxes are of phosphor bronze, lined with babbitt metal well grooved for oil. The axle boxes are made to suit a 6½-in. axle and are 12 ins. long.

Armature and axle bearings are lubricated by oil fed to the journals by waste, in accordance with standard railway practice. The oil boxes are formed so that the waste will pack itself against the journals. The oil box covers are lipped and hinged, and fitted with springs that keep the lids tightly closed or hold them open as desired. Drip boxes are provided to catch all waste oil so that no oil can get into the motor.

The gears are solid, of cast-steel, with cut teeth. The diametrical pitch is 2½ per inch, and the face is 5 ins. The pinions are forged steel with cut teeth. They are taper bored to fit the shaft and are held in place by a nut and lock washer. The diameter of the shaft at the large end of the taper is 4⅜ ins. The gear case is made of malleable iron planed to a tight joint, with a suitable opening at top, having a hinged cover. It is supported at the ends by horns cast on the motor frame, and so shaped that they support the gear case without side strain, the weight being carried on its own plane. The whole motor can be dismantled with great ease and despatch without the use of any special tools. The total weight of motor, gear, gear case, etc., is about 6600 lbs.

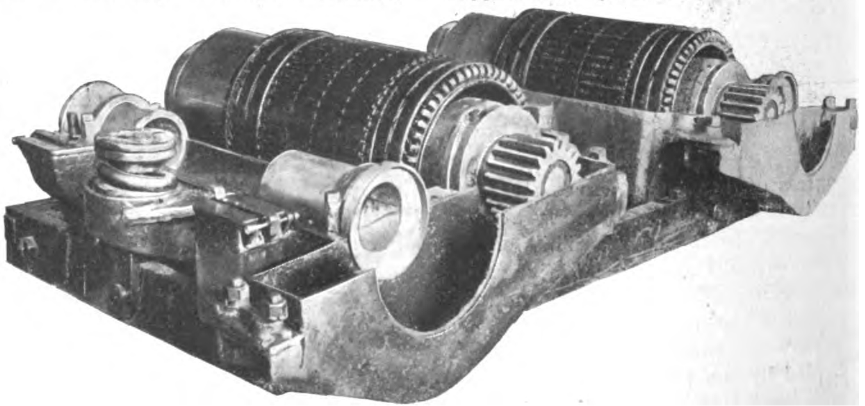


FIG. 10.—NO. 86 MOTORS, WITH UPPER FIELDS REMOVED.

GENERAL ELECTRIC MOTORS FOR RAPID TRANSIT SUBWAY.

The accompanying illustrations show the type of motor which will be supplied by the General Electric Company for the cars of the Rapid Transit Subway. There will be 340 of these motors used, two to each car, having an aggregate capacity of 400 horsepower. Each motor is fitted with the nose suspension, and its front side is supported by lugs cast on a frame. This lug is designed to rest on a bracket riveted to the truck transom with a forged strip bolted over the top of the lug to prevent the motor from rising. The motor is mounted on or removed from the truck from above, when the truck is out from under the car, no pit being required.

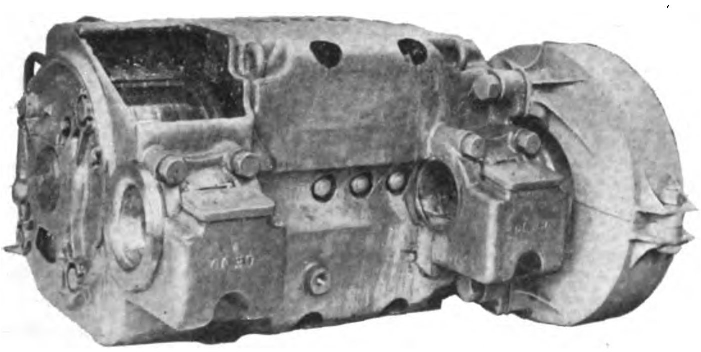


FIG. 11.—AXLE END OF MOTOR.

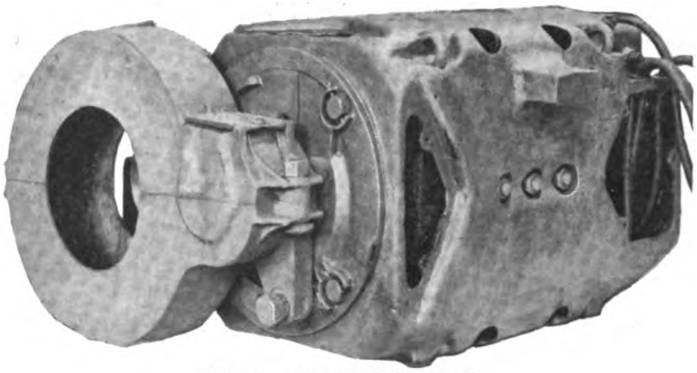


FIG. 12.—SIDE VIEW OF MOTOR.

The magnet frame is unsplit, and is made of one piece of cast-steel, substantially in the form of a cube with well-rounded corners and large bored openings, one at each end, into which frame heads carrying the armature shaft bearings are bolted. Through these openings the armature is put in place or removed from the frame. The pole pieces are laminated and are bolted to the interior, top, bottom and sides of the frame with through bolts with nuts on the outside of the frame. The field coils are wound with flat copper ribbon in a common plane. The coils are insulated with mica and a specially prepared fabric which makes them semi-fireproof and practically impervious to moisture. The air-gap is a total of 7-16 in., 3-16 of an inch above and 4-16 of an inch below the armature.

The armature has a series drum barrel winding. Its conductors are copper bars, separately insulated and assembled in sets of five, the set as a whole having an outside protective insulation. The bars are soldered directly into ears, forming a part of the commutator segments, thus avoiding entirely the use of connecting leads. At the back of the armature the top and bottom bars are connected together with tinned clips riveted and soldered but easily removable in case it should be desired to replace top bars without disturbing the bottom bars. The conductors are held in slots by tinned steel wire bands imbedded in the core beneath the periphery, the wires being soldered together and held by tinned clips. The armature core is of the "iron-clad" type, and is made up of soft iron laminæ. The commutator segments are made of hard-drawn copper insulated throughout with the very best grade of mica. The commutator shell and cap are made of cast-steel, the parts being especially strong; the segments are clamped very tight, the cap being pressed home in a hydraulic press previous to tightening the commutator bolts. The commutator ears, into which the armature conductors are soldered, are formed integral with the segments so that there is no joint between the ears and segments.

The brush holders are made of cast bronze, and are adjustable to allow for wear of the commutator. The heads carrying the armature shaft bearings are each made of malleable iron cast in one piece. In order to secure large and long bearings without sacrificing other desirable features of construction, the heads in a cone shape are extended well under the commutator shell and pinion and armature core head. This construction forms a support for the bearing lining, which is very strong and rigid.

The armature bearing of the motor bearing is open to lubrication only on the side opposite the shaft pressure. The babbitt lining is only 1-16 in. thick, preventing the armature dropping more than this distance even in case of hot bearings melting out the babbitt. The bearing is soldered into a shell of the best quality bearing bronze by first tinning the inside of the shell before pouring in the babbitt.

The gears are made of a superior grade of cast steel and the pinions are forged steel, extra hammered to improve the quality of the metal. This material has an elastic limit of not less than 38,000 lbs., and a tensile strength of about twice that amount. The gears have a 5¼-in. face and are cut with 2½-in. diametrical pitch. The pinion has a taper fit on the armature shaft of ⅝ in. to the foot, measured radially. The gear case is of substantial construction and is bolted directly to the frame of the motor without the use of lugs. This form of construction was introduced by the General Electric Company for the first time on the Manhattan Railway, and has given very good satisfaction, as it avoids all possibility of the breaking of lugs. The gear case is of malleable iron, and radiating from the three points at which it is attached to the motor frame are strengthening ribs to prevent the case from cracking when subjected to the excessive vibration received in service. Both top and bottom halves of the case are bolted to the motor frame and the two halves are bolted together.

Another very important feature of this motor is the method which has been adopted to overcome the trouble popularly known as "flashing over." As is well known, it has been the practice heretofore to place around the field poles of the motor short-circuited copper bands for the purpose of steadying the motor, and also, though not of the first importance, to reduce the arcing at the controller. With the type of control used, the contact resistances are of such a character as to possess ample margin to take care of any self-induction, however great. The use of these copper bands is, therefore, unnecessary so far as the controller is concerned. They have, therefore, been omitted, and where the field winding is supported by or surrounded by a metal shell for mechanical support, the shell is cut or open-circuited so as to prevent its acting as a short-circuiting conducting band around the poles. In other words, the effect has been to make the self-induction of the motor sufficiently great to prevent a sudden inrush of heavy current in case of the momentary interruption of the power circuit.

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NEW BOOKS.

ELECTRICAL PROBLEMS. By Wm. L. Hooper and Roy T. Wells. Boston: Ginn & Co. Buckram; 170 pages, 5½ ins. x 8 ins.; 88 diagrams. Price, $1.25; $1.35 postpaid.

This is a collection of problems in electricity arranged for engineering students. Besides the problems, the book contains much valuable information in condensed form. At the beginning of each of the twenty-six chapters is given an outline of the principles applicable to the problems immediately following, with such formulas as are needful for their solution; and throughout the text, brief explanations of the more difficult problems are inserted. A number of diagrams are given illustrative of the graphical method of solving problems and comparing results. The arrangement of the matter is excellent, beginning with the simple problems relating to direct currents and leading by gradual steps to those applying to alternating currents, dynamos and transformers. The problems are, for the most part, practical ones such as would be met with in engineering work, and the book throughout is exceptionally free from matter which, while of interest from a purely theoretical standpoint, is absolutely valueless practically. Some of the statements are not so clear as they might be, and in many places it is difficult to tell what units should be used when values are substituted in the formulas; and, as the authors state in substance in the preface, that one of the main objects of the book is to enable students to make practical application of formulas, it would seem advisable that to this end the formulas themselves should be made as simple and easy of comprehension as possible. In the consideration of alternating-current phenomena, it would have been well to give in addition to the graphical vector method the algebraic vector analysis, which is of great value in the solution of many problems. Altogether the work is a meritorious one and will be very convenient for use in connection with the theoretical part of courses of instruction in electrical science, particularly in cases where students do not have the advantages of a laboratory and a chance to work up the results from observations which they themselves have made.

Mechanical Engineer's Pocket Book. (1903 edition.) By Wm. Kent. New York: John Wiley & Sons. Flexible leather; 113 pages, 4 ins. x 7 ins.; 192 illustrations. Price, $5.00.

Kent's Pocket Book needs neither introduction nor commendation to readers of the American Electrician. The present edition is the sixth, and contains a considerable amount of new material. The sections on Friction and Lubrication, the Steam Engine, Cast Iron, and the Locomotive have been enlarged and the chapter on Electrical Engineering has been revised and greatly extended. Much of the new material in this latter chapter is excellent, but some of it is not well chosen and a few of the formulas and methods retained or added are actually obsolete. Amongst the out-of-date material retained from the old edition may be noted Hering's rule for coil heating, deduced about ten years ago from observations of dynamo magnet coils as *then* built, storage-battery practice in the 53rd Street Edison station in 1893, the discussion of the Kapp unit of magnetic lines of force, which no designer thinks of now-a-days, unless Mr. Kapp himself may; and the reference to "practice" in the design of bipolar dynamos of 200 and 300 kilowatts. Kirchhoff's Law and Dix's formula for magnet coil heating, two of the best features of the electrical chapter in older editions, have been omitted, and an elementary definition and discussion of series and parallel circuits, of no value to any but amateurs or first-year students, have been inserted. The data relating to commercial generators and motors is useless because significant dimensions are omitted; in fact, the final five pages of this chapter are hopelessly perfunctory. With the exception of a part of the alternating-current section (all of which is new) and such statements of fundamental laws as have been retained, the electrical engineering chapter gives obtrusive evidence of a lack of judgment on the part of the compiler. No one regrets this more than the reviewer, whose appreciation of the steam and mechanical engineering divisions of the book is unstinted.

OBITUARY.

J. HOBART HERRICK, who was vice-president of the Edison General Electric Company from 1899 until the General Electric Company was formed in 1892, died recently in New York City, as the result of a fall at the Union League Club. Mr. Herrick was 69 years old.

EVERTON B. ARNOLD, a brother of Mr. Bion J. Arnold, died on March 9 at Loch Haven, Pa., from typhoid-pneumonia, after a very short illness. Mr. Arnold was only 31 years old at the time of his death, and had occupied a responsible position with the Arnold Electric Power Station Company since the formation of the company. He was just finishing up an important piece of work at the Oak Grove shops of the New York Central

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PERSONAL.

MR. GUY W. BUXTON, who has been a member of the New York staff of the H. W. Johns-Manville Company for some time, was recently appointed to the position of auditor of the company.

MR. B. B. WHITE recently resigned his position as superintendent of the Thomaston Electric Light & Power plant to accept a similar position with the lighting and water plant of the city of Starke, Fla.

MR. JOHN DAVIDSON, formerly of the Germania Electric Lamp Company, has joined the staff of the Sterling Electrical Manufacturing Company, Warren, Ohio, and is located at the New York office of the company, 25 Cortlandt Street.

MR. C. E. LEFEBVRE has been appointed manager for the Engineering & Equipment Company, Pittsburg, and has charge of the electrical and mechanical supply, construction and engineering business of the company.

MR. ARTHUR B. LISLE, formerly sales and collecting agent of the Narragansett Electric Light Company, Providence, R. I., has been advanced to the position of assistant general manager of that company.

MR. R. J. HEWETT, who has been connected with the telegraph department of the Missouri Pacific Railway Company for several years, has accepted a responsible position with the Hall Signal Company, New York.

MR. EDWARD BLAIR has resigned the position of assistant to the general manager of the Quebec Electric Railway, Quebec, Can., to accept that of assistant superintendent of the Montreal Street Railway, Montreal, Canada.

MR. T. K. GLENN, second vice-president and secretary of the Georgia Railway & Electric Company, Atlanta, Ga., has been advanced to the position of first vice-president and has also been made manager of the railway department of the company.

MR. CHARLES S. PROSSER, who has been connected with the Peerless Rubber Manufacturing Company, New York, for many years, having spent five years in the company's factory and five years on the road, was recently made general sales agent of the company.

MR. CHARLES S. POWELL, who has been manager of the Westinghouse Electric & Mfg. Company's Cleveland office for the past six years, has been appointed assistant manager of the British Westinghouse Electric & Manufacturing Company, with headquarters in the Westinghouse Building, Norfolk Street, Strand, London, W. C. Mr. Powell has already entered upon the duties of his new position.

MR. H. O. SWOBODA, who was for several years chief engineer of the Falcon Electric Manufacturing Company, has devoted a large part of his time during the past twelve months to the development of a new line of knife switches, panel-boards and switchboards, and has now arranged with the National Brass & Iron Works, Reading, Pa., to manufacture this line according to his specifications. Mr. Swoboda has established The H. O. S. Engineering Company, at 277 Broadway, New York, where all business pertaining to the new line will be transacted.

TRADE PUBLICATIONS.

FAN MOTORS. Westinghouse Electric & Manufacturing Company.—The 1903 fan-motor catalogue of this company, containing finely-executed half-tone illustrations of the complete line of machines built this year. These were described in the fan-motor article last month.

METAL WORKERS' CRAYONS. The D. M. Steward Manufacturing Company, Chattanooga, Tenn.—A pamphlet containing illustrations and prices of crayons for marking on metal. Two grades of crayon are manufactured, one of genuine soapstone and the other of a composition known in the trade as "Compo."

MERIDIAN LAMP. General Electric Company. —This is bulletin No. 3314, in which is illustrated and described a new type of incandescent lamp known as the Meridian lamp and designed to meet the demand for a lighting unit of higher candle-power than the ordinary incandescent lamp and lower than the smaller arc lamps.

AS COOL AS A CUCUMBER. The Emerson Electric Manufacturing Company, St. Louis, Mo.—This is a vest pocket pamphlet containing some strong arguments in favor of the Emerson fan motors. It also contains miniature but well-executed engravings illustrating every form of fan motor built by the company.

FAN MOTORS. General Electric Company.—This is the 1903 edition of the General Electric Company's catalogue and is executed in the beautiful style characteristic of this company's publications. The line of machines built this year does not differ greatly from that of a year ago, as pointed out in the fan-motor article which appeared last month.

INTERIOR CONDUIT.—Sprague Electric Company, New York.—Catalogue No. 410, devoted to the well-known iron-armored and brass-armored insulating conduit, Greenfield flexible metal conduit and unarmored conduit, and junction boxes, terminal boxes, elbows, couplings, and other fittings for the different types of conduit. The catalogue also includes illustrations and price-lists of conduit fitting tools.

BITUMINIZED FIBER CONDUIT. American Conduit Company, Philadelphia.—This is an attractive booklet executed in handsome style and containing instructive remarks on the use of conduit and an interesting description of the bituminized conduit made by this company. The book is profusely illustrated and contains also some important data taken from reports of tests made with bituminized and other conduits.

TRANSFORMERS. Kuhlman Electric Company, Elkhart, Ind.—A catalogue of the transformers built by this company, containing a full illustrated description of the transformers, charts showing regulation efficiency and energy loss curves, and a short chapter devoted to the company's method of doing business, which includes the giving of a rigid two-year guarantee with each transformer.

ELECTRIC HOISTS. C. W. Hunt Company, New York.—This is catalogue No. 0225, containing a well-illustrated description of the various types of motor-driven hoisting machines built by this company. The line is a very complete one, embracing winches, hoists for mining, ship loading and unloading, handling coal, gravel and similar material, etc., and arranged to be driven by spur or bevel gears according to the requirements of the case.

AUTOMATIC TELEPHONE SYSTEM. The Clark Automatic Telephone Switchboard Company, Providence, R. I.—A catalogue devoted to this system, which was fully described some time ago in the New Apparatus department of this paper. The catalogue contains, in addition to illustrations of the various pieces of apparatus comprising the system, many testimonial letters from users of the Clark system, among which may be noted two extremely favorable letters from the Societe Alsacienne de Constructions Mecaniques, of Paris, France, and the Stanley Electric Manufacturing Company.

NEW KNOWLEDGE ON BELT MANAGEMENT. Cling Surface Manufacturing Company, Buffalo.—This is a well-executed and very pithy little book of some sixty pages, containing information concerning "Cling Surface" and the operation of belts in general, which can scarcely fail to be both interesting and valuable to belt users. The book contains several convincing illustrations of belts in actual use showing some remarkable results obtained by the use of "Cling Surface."

WIRES, CABLES AND MOULDINGS. K. & B. Company, Philadelphia.—This is an extremely convenient folder containing tables which show the outside diameters of twisted pair telephone cables, double and triple-braid weather-proof wires, single-braid and double-braid rubber-covered wires and Moore's slow-burning fire and weather-proof wire. The folder also contains full-size illustrations of the large line of electric light wire mouldings carried in stock by the K. & B. Company.

CONDUIT COMMENTS. Standard Vitrified Conduit Company, New York.—A finely executed pamphlet containing illustrations of the various forms of conduit made by this company and considerable information concerning clay conduit in general and Standard vitrified conduit in particular. The company has also issued a handsome catalogue of its product, which contains, in addition to a complete description of the conduit, several pictures of notable installations.

FUEL OIL BURNERS. The National Oil Burner and Equipment Company, St. Louis, Mo.—This is catalogue No. 4, containing an illustrated description of furnace burners, oil heaters and other equipment for use in connection with boiler furnaces fired with crude oil, distillate or kerosene, with either steam or air. The catalogue also contains illustrated descriptions of domestic burners adapted for house furnaces, stoves, ranges, etc., crude oil and kerosene burners for automobiles, and burners for tempering and hardening furnaces.

ELECTRICAL SUPPLIES AND APPARATUS. Western Electrical Supply Company, St. Louis, Mo.—This is the Western Company's general supply catalogue No. 50 and is a superb specimen of this class of catalogue. It is the rule rather than the exception to find general catalogues illustrated by the poorest possible class of engravings, and with the material arranged in hodge-podge fashion; this is not the case with the catalogue under review. The illustrations are mostly well executed, the material is classified intelligently, and the pages are sufficiently large to prevent the necessity of breaking up a price-list into two or three sections. The lines of apparatus, fittings and materials included in the catalogue are much too extensive to permit enumeration.

SWITCHES, FUSE BLOCKS, PANEL-BOARDS, ETC. W. S. Hill Electric Company, New Bedford, Mass.—This is a complete set of bulletins ranging from No. 102 to No. 119 inclusive, and containing illustrations, descriptions and price-lists of the extensive line of switches, fuse-blocks, etc., made by this company. The company's line has been completely remodeled since January, 1902, improvement having been made in every detail where this was practicable. The line of switches includes the simple single-blade type, switches with a multiple blade for each terminal, switches with auxiliary quick-break blades, switches known as Style R having re-enforced contacts, and a line of switches built especially for high-voltage circuits and provided with very substantial arms and hinges of malleable iron, the copper knife-blades being mounted on the iron arms. This construction is employed in order to make these switches rigid and durable without making the copper blades of larger cross-section than is necessary for electrical purposes. The line of tablet-boards and fuse-blocks is similarly complete, embracing forms appropriate for every modern method of distribution.

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BUSINESS NEWS

THE COMMERCIAL ELECTRIC COMPANY, Indianapolis, Ind., has purchased the factory plant formerly occupied by the Alfree Engine Company, which is well equipped with large machine tools and will very greatly increase the Commercial Company's manufacturing facilities.

THE BALL & WOOD COMPANY, builders of automatic cut-off engines, will move its New York offices on May 1, from 120 Liberty Street to the Whitehall Building, 6 Battery Place.

THE AMERICAN MINIATURE AND DECORATIVE LAMP COMPANY, New York, has been incorporated by H. J. Jaeger, C. Hubert and Samuel Stern, with a capitalization of $100,000.

ROYAL ELECTRIC COMPANY, Peoria, Ill., reports among recent sales one of a 180-kw. alternator to the city lighting plant of Lebanon, Ohio, and a 120-kw. alternator to the city of Newton, Ill.

THE SACHS ELECTRIC COMPANY, St. Louis, Mo., has been appointed agent for the Helios-Upton Company, of Philadelphia, Pa., and will control all of the specialties of that company within its territory.

THE VOUGHT-BERGER COMPANY, La Crosse, Wis., reports a great increase in sales of "Two Balls" card adjusters. The railroad and telegraph companies are now considering using this form of adjustable fixture.

DODGE & DAY, Philadelphia, have been commissioned by the Ingersoll-Sergeant Drill Company to report on variable speed motor equipment for its new Phillipsburg plant, and have been awarded the contract to equip a number of the large machine tools with motor drives.

ELBLIGHT COMPANY OF AMERICA, New York, announces that the Elblight system has received the approval of the electrical committee of the National Board of Fire Underwriters, and that rules applying to the use of this system will be incorporated in the next issue of the National Code.

THE EUREKA ELECTRIC COMPANY and the ADVANCE ELECTRIC & TELEPHONE COMPANY, both of Chicago, have consolidated with a total capital of $150,000, and will remove to Genoa, Ill. A two-story brick factory building, 96 x 225 feet, will be erected, and about 40 dwelling houses for employees will be built.

BINGHAM & CO., Camden, N. J., manufacturers of sheet metal specialties for steam and electric plants, have been compelled by increase in business to seek more commodious quarters and better factory facilities, and have accordingly secured the buildings and plant of the Camden Machine Works at Delaware and Cooper Streets, where the firm's works are now located.

COLUMBIA ELECTRIC & MANUFACTURING COMPANY, Newark, N. J., maker of the Columbia enclosed arc lamp, has moved from its temporary quarters at 316 Market Street to a new factory building at the corner of High Street and Boyden Place, one block south of Orange Street, and invites everyone interested in arc lamps to visit the new factory and inspect the Columbia lamp.

JAMES G. BIDDLE, Philadelphia, announces that Morris E. Leeds & Co., for whom he is sales agent, have taken up the manufacture of a new conductivity bridge designed by Mr. William Hoopes, engineer of the Pittsburg Reduction Company, and Mr. Biddle is now prepared to fill orders for this apparatus. Mr. Biddle has moved his office from the Stephen Girard Building to No. 1114 Chestnut Street.

THE R. M. CORNWELL COMPANY, Syracuse, N. Y., has removed its store from No. 347 West Fayette Street to No. 332 in the same street. The new quarters will give the company a main store 120 feet deep and 40 feet wide, with four lofts, and it is the intention to carry the largest stock of electrical supplies in the central part of New York State. The company will also carry a large number of second-hand machines in stock.

WESTERN ELECTRIC COMPANY has been awarded an important contract for series alternating-current arc lighting apparatus by the city of Columbus, Ohio. The equipment to be furnished includes 1500 enclosed arc lamps, and the transformers, regulators and complete switchboard equipment for operating these lamps on 75-lamp circuits. The manufacturers feel particularly gratified by the award for the reason that it was made after a comparison of various equipments which were tested in actual operation.

WESTERN ELECTRICAL SUPPLY COMPANY, St. Louis, Mo., announces that in addition to the well-known Peerless direct-current desk and ceiling fan motors, it is carrying in stock this year the alternating-current fan motors built by the Peerless Electric Company. This machine is said to be the only alternating-current fan on the market which has three rates of speed. Its construction is, of course, of the same high class as that which characterizes the other Peerless machines.

THE LAGONDA MANUFACTURING COMPANY, Springfield, Ohio, recently received the following enthusiastic testimonial from one of the engineering periodicals: "A thorough engineer invented the Weinland tube cleaner. That's what makes it so popular among engineers and keeps the Lagonda Manufacturing Company busy filling orders. Mr. Weinland knew from years' experience as an engineer what was needed in this line and he built one, and now his company is building thousands."

BROWN-CORLISS ENGINE COMPANY, Corliss, Wis., at a special meeting of its directors held recently, decided to increase its capitalization immediately from $1,000,000 to $1,200,000, in order to obtain sufficient working capital to handle the immense quantity of large work now on hand and within reach. Work has been offered to the company that runs into the largest types of engines, which require about six months to build, and therefore tie up large sums of money. Hence the chief necessity for the increase in capital stock.

JAMES McCREA & CO., Chicago, announce the receipt of large stock orders for H. H. steam traps from James Beggs & Co., New York; New England Lubricant Company, Boston; John B. Adt, Baltimore; Barrett & Plowman, Philadelphia; Edward Joy, Syracuse; Pittsburgh Gage & Supply Company, Pittsburg; James Walker & Son, Detroit; Chafer & Becker, Cleveland; Central Supply Company, Indianapolis; Atlanta Supply Company, Atlanta; Laib Company, Louisville; Cameron-Barkley Company, Charleston; Andrew F. Gregg, Cincinnati; Robert Rom Company, Milwaukee.

THE GEORGE W. LORD COMPANY, Philadelphia, Pa., was incorporated recently to succeed to the business in boiler compounds which has been built up by Mr. Lord to an astonishing magnitude. The officers of the new company are: George W. Lord, president; L. M. Lord, vice-president; V. O. Lawrence, secretary and treasurer. The business has grown to such an extent during the past few years that branch offices have been established throughout the United States and in many foreign countries, and booklets printed in Spanish are circulated in all countries where that language is spoken.

D. L. BATES & BROTHERS COMPANY, Dayton, Ohio, was recently incorporated to succeed the well-known firm of D. L. Bates & Bro., manufacturers of the well-known Bates fan motors. The officers of the new company are: D. L. Bates, president and general superintendent; Russell H. Bates, vice-president and general manager, and A. L. Bates, secretary. The company has recently made several additions to its factory and is in position to fill promptly orders of any size for fan motors either electrical or hydraulic. The company has also arranged to put on the market shortly a line of high-grade direct-current power motors ranging from 1/4 horse-power to 3 horse-power, in slow, medium and high speeds.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago, reports a brisk business in its line of work. The company recently closed contracts for telephone apparatus with the Bergholz (Ohio) Telephone Company, Winona (Ohio) Telephone Company, Wataga (Ill.) Mutual Telephone Company, Gays (Ill.) Mutual Telephone Company, Cullom (Ill.) Mutual Telephone Company, Fairbury (Ill.) Farmers' Telephone Company, Millikan & Stokes Telephone Company, Edinburg, Ill.; Central Illinois Telephone & Telegraph Company, Lincoln, Ill.; and the Farmers' Mutual Telephone Company, Ashmore, Ill. At a recent meeting of the company's stockholders it was voted to increase the capital stock from $3,000,000 to $4,500,000, in order to better handle the rapidly growing business.

WILLIAM F. BREWSTER, patentee of the well-known universal sign receptacles which bear his name and have been heretofore manufactured by the Electric Motor & Equipment Company, Newark, N. J., announces to the trade that these appliances are no longer manufactured by the Newark company and that an improved type of Brewster sign receptacle will soon be put on the market.

I. P. FRINK, New York, has recently completed a notable installation of reflectors in the American Art Galleries, New York, and the new galleries of the Drexel Institute, Philadelphia. Mr. Frink has also equipped the delivery room of the Boston library with reflectors for the purpose of illuminating Mr. Abbey's Holy Grail decorations. In the line of show window and show case reflectors, the Frink system continues to be widely used. Among representative stores in which this system has been installed may be mentioned the new stores of R. H. Macy & Co. and Saks & Co., New York; the Adams Dry Goods Company, John Wanamaker, the Siegel-Cooper Company, Simpson-Crawford Company, and Rogers, Peet & Co., New York; Gimbel Brothers and Snellenburg & Co., Philadelphia; Hannifin Dry Goods Company, Milwaukee, and Panton & White, Duluth, Minn.

THE OTIS ELEVATOR COMPANY, New York, has been awarded the John Scott Legacy Medal and Premium by the Franklin Institute for its electric elevator for private residences, which dispenses with the services of an attendant and is operated by merely pushing buttons at the various landings and in the car. The Committee on Science and the Arts, which recommended the award, made a thorough inspection of several existing installations and their report is highly commendatory of the ingenuity of design, the safety of operation and the substantial construction of this apparatus. The Otis Company recently closed a contract for eighteen electric elevators, with push-button control, which is said to be the largest number of elevators of this type ever included in a single contract. These elevators are to be installed, one each, in a row of private residences now being constructed for F. Ambrose Clark on West 74th Street, New York.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, recently closed several large contracts for the installation of storage batteries in connection with street railway work on the Pacific Coast. The Los Angeles Railway Company has contracted for three batteries, two consisting of 264 cells having a capacity of 1,000 amperes and one of the same number of cells having a capacity of 2,000 amperes. These batteries are to be operated in connection with differential boosters for regulation purposes on the railway load and for reserve in any emergency which may arise, due to the temporary shut down of machinery at the power house. The Pacific Electric Railroad has also contracted for a battery of "Chloride" accumulators consisting of 264 elements of 1000 amperes capacity, to be operated in connection with a differential booster for regulation, peak work and emergency use. Several batteries are now in process of installation for the Oakland Transit Consolidated, the Los Angeles Pacific Railway and the North Shore Railroad, all in that section.

THE AUTOMATIC ELECTRIC COMPANY, Chicago, has received an order for immediate delivery from the Imperial Telephone Exchange, which is managed by the Postal Department of the German Government, for 1070 automatic telephones and switches to be used in extending the automatic telephone service in Berlin. The exchange which is to be enlarged has been in operation since May 20, 1900; it was built by the Automatic Company, and operated until July, 1901, under the auspices of German telephone engineers, at which time it was purchased by the Government. The Automatic Company has also received an order from the Delaware County Telephone Company, of Manchester, Ia., for an automatic switchboard of 1000 lines capacity with an initial installation of 300 lines. Manchester has had automatic telephone service for seven years, the Delaware County Company being one of the early purchasers of automatic apparatus. The business has outgrown the ultimate capacity of the old board, and the new equipment was purchased to meet the increasing demand for service.

THE ALBERGER CONDENSER COMPANY, New York, has acquired control of the Newburgh Ice Machine & Engine Company, Newburgh, N. Y., which has been long and favorably known as a builder of Corliss engines, ice machines and other high-class machinery. It is understood to be the intention of the Alberger Condenser Company to devote the acquired works principally to the manufacture of improved condensers, vacuum pumps and Corliss pumping engines, which the company is using extensively in connection with high vacuum condenser installations. Recent developments in this class of work all tend toward the improvement of the parts that make up the condensing equipment. This has been largely brought about by the demand for an extremely high vacuum in connection with steam turbines and the inability of the old types of apparatus to accomplish efficiently the results required. The Alberger Condenser Company still retains close connection with the Quintard Iron Works, of New York, but rapidly increasing business has made it necessary to obtain the additional facilities for the manufacture of special lines of work.

ALLIS-CHALMERS COMPANY, Chicago, reports among the engine sales for the month of February the following: Bucyrus Company, South Milwaukee, Wis., one 16 x 42, 1890 frame, engine; Southwestern Missouri Electric Railway Company, Webb City, Mo., one 30 and 60 x 48 horizontal cross-compound direct-connected engine; Albert Schwill & Co., Chicago, two 26 x 48, 1890 frame, direct-connected engines; Wausau Paper Company, Brokaw, Wis., one 16 x 36, girder frame, engine; Vulcan Iron Works, San Francisco, Cal., one 14 x 36, girder frame, engine; the S. Obermayer Company, Cincinnati, Ohio, one 20 x 48, girder frame, engine; Geo. M. Moulton & Co., Chicago, one 24 and 48 x 48 steeple compound engine; Javril Company, Battle Creek, Mich., one 12 x 30, girder frame, engine; Louisville Railway Co., Louisville, Ky., two 40 and 78 x 60 vertical cross-compound direct-connected engines; James Davidson, West Bay City, Mich., one 16 x 42, girder frame, engine; Denison Light & Power Company, Denison, Texas, one 16 x 36, 1890 frame, engine, and Albuquerque Gas, Electric Light & Power Company, Albuquerque, N. M., one 16 and 28 x 36 horizontal cross-compound direct-connected engine, all of the Reynolds-Corliss type.

THE WESTON ELECTRICAL INSTRUMENT COMPANY, Newark, N. J., for the greater convenience of its numerous customers and to better care for the continued increase of business in New York and vicinity, has opened a New York office at 74 Cortlandt Street, under the management of Mr. Caxton Brown, who has a theoretical as well as a practical knowledge of the different instruments manufactured by the Weston Company and their particular adaptabilities. This will enable anyone visiting or doing business in New York who may wish to make inquiries relative to Weston instruments to obtain intelligent and authentic information concerning them. There will be a showroom in connection with the New York office in which will be exhibited the different types of Weston instruments and the individual parts which make up the instruments. A general impression has prevailed that the Weston Electrical Instrument Company only makes voltmeters and ammeters, which is not the case. Having one of the largest and best equipped factories in the world for the production of electrical measuring instruments of all kinds, the company is in position to turn out work of any special character in which the highest excellence of mechanical and electrical work and design are the important features. The Weston factory has, in fact, been turning out a large amount of special laboratory apparatus for several years past and now has facilities for making standard cells, standard resistances, galvanometers, the highest grade of special bridge work, speed indicators, etc.

SOLID TRAINS TO NORTHERN MICHIGAN.

The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.

All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

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INDUCTION MOTORS IN A PLATE GLASS FACTORY.

ISOLATED PLANT OF THE EDWARD FORD PLATE GLASS COMPANY.

BY J. R. CRAVATH.

One of the largest isolated plants in the United States is that of the Edward Ford Plate Glass Company, situated at Rossford, Ohio, just outside of Toledo. The power station supplying electrical energy to these works has a capacity of 4350 kilowatts, so that the station is larger than would be required for driving all the electric cars in a city of 100,000 population. The amount of power required in the manufacture of plate glass is a surprise to the uninitiated, enormous power being required for polishing the glass. In making plate glass, the molten glass is poured on a table and rolled to the desired thickness. The glass is then annealed by slow cooling in ovens, from which it emerges with a surface about as rough as a piece of smooth cast iron. The glass is then put upon immense tables, and these tables are revolved under polishing wheels, which also revolve. Sand is used as a polishing material at first, and in the later stages rouge is substituted for the sand; it is this polishing and grinding that takes such an immense amount of power.

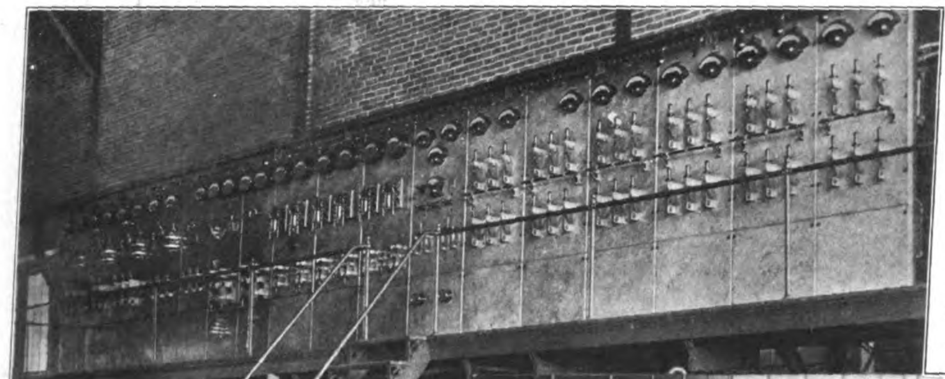

FIG. 1.—SWITCHBOARD.

It is unnecessary to enumerate all of the motors in these works, but some idea of the average size of the motor units may be obtained from the fact that there are twenty motors of 450 horse-power each, twenty of 200 horse-power each, ten of 50 horse-power each, and fifteen of from 5 to 10 horse-power; the motors of large capacity are employed in driving the polishers and grinders. These machines are all three-phase induction motors. The conditions in this class of manufacture are such that the work would be very trying for direct-current motors, on account of the escaping gases and products of combustion from the furnaces in some places, and the dust which collects in other places.

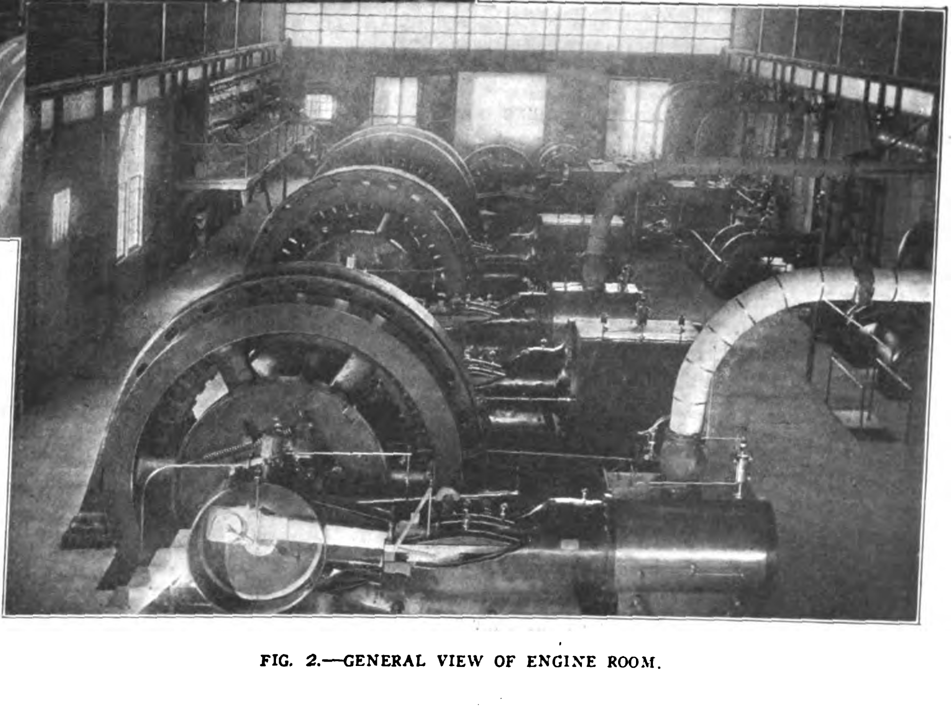

FIG. 2.—GENERAL VIEW OF ENGINE ROOM.

Aside from the size of the motors used, this installation is chiefly of interest because of the variable speeds which are obtained from the induction motors. The motors are wound for two speeds at a frequency of 40 cycles, but since for polishing glass three speeds are needed, an additional current supply is provided at 25 cycles, which gives the third speed rate. When the polishing table is first started, its motor is connected to the 25-cycle circuit. Later, it is thrown on the 40-cycle circuit at slow speed, and finally brought to full speed on the 40-cycle circuit. The motors are started with the polishing wheels down on the glass plates, and this necessitates a starting torque equal to or exceeding the running torque. The controllers are similar in external appearance and operation to street railway controllers, and they make the various combinations required by the three speeds on a contact drum, as do street railway motor controllers. The main circuit, however, is broken by a special switch operated by a movement of the controller handle, this switch taking all of the arcing, and so relieving the contact drum from deterioration due to that cause.

It seems that the manufacture of plate glass is another one of the industries to which electric driving is especially suited. The transmission of the large power required to drive the various polishing machines by means of belts and shafting would involve exceedingly cumbersome apparatus, when the necessity for varying the speed is considered. In fact, the difficulties of belt transmission were so great that previous to the introduction of the electric motor drive it was customary to place a steam engine at every polishing machine, each machine being individually driven by its own engine. Of course, this was a very uneconomical arrangement, because of the long distances to which steam had to be piped, and the low efficiency of steam engines when working under such conditions.

The power plant of this company contains four generating units of 1000 kilowatts and one of 350 kilowatts. These generators all give three-phase, 40-cycle currents at 580 volts. There is also a motor-generator, the motor of which is a 40-cycle, 300-horse-power machine; this drives a 25-cycle, 330-volt alternator and a direct-current generator having an output ability of 800 amperes at 125 volts. This generator can be used as an exciter, and it regularly furnishes direct current to some travelling cranes and transfer cars. The 25-cycle current is used, as previously stated, to obtain the lowest speed for the induction motors.

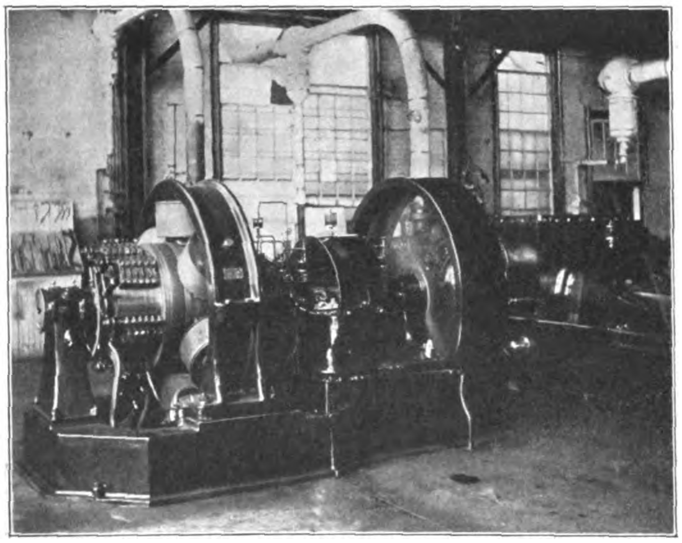

FIG. 3.—ENGINE-DRIVEN EXCITER.

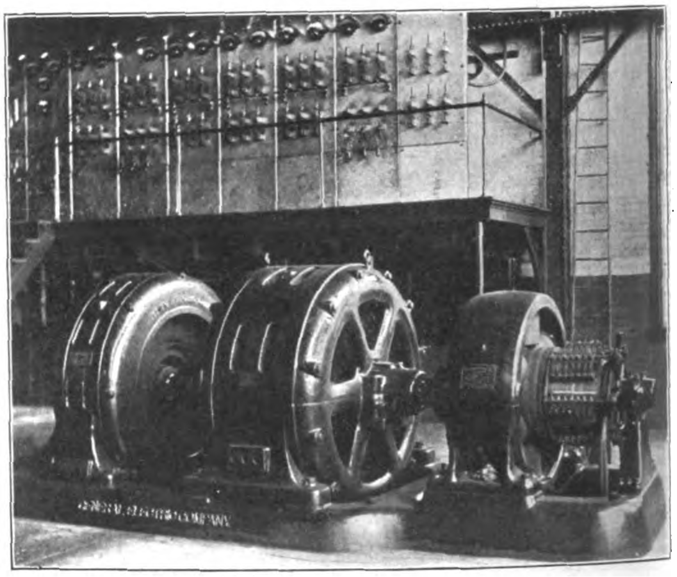

FIG. 4.—MOTOR-GENERATOR SET.

The incandescent lighting of the works is supplied from the direct-current dynamo. Two of the large alternators are driven by Russell cross-compound condensing engines of 1500 horse-power, and two by McIntosh & Seymour compound condensing engines, one of the latter being a cross-compound and the other a tandem-compound. The speed of all these units is 120 r.p.m. An exciter dynamo giving 800 amperes at 125 volts is driven by a Ball (Erie) high-speed 150-h.p. engine. The ordinary operation of the plant calls for the running of the four 1000-k.w. units simultaneously, but they are not ordinarily run in parallel.

The design and construction of the electrical plant was carried out by F. B. Perkins, an electrical and mechanical engineer, who has been prominently connected with electric railway work around Toledo for several years past. The generating and motor equipment is all of General Electric manufacture.

SOME DIFFICULTIES OF LONG DISTANCE ELECTRIC TRANSMISSION.

BY PAUL M. LINCOLN.

The difficulties in long-distance transmission may be subdivided into those which are imposed by man and those which are imposed by nature. The man-imposed limitations are such as malicious interference, carelessness and the use of bad or inadequate methods. The natural limitations on the other hand are those imposed by the problem of insulating for high voltages, of taking care of lightning discharges and of the relative cost between electrically-transmitted power and that generated at the point where it is to be used. While perhaps not the most frequent, certainly the most exasperating trouble that a transmission line manager can encounter is malicious interference. It is a difficulty over which an improvement in methods has little effect, and an improvement in apparatus has none. Sometimes such trouble arises from an actual intention to do harm, as for instance a feeling of spite on the part of a discharged employee. More often, however, the culprit does not realize the amount of damage and inconvenience his careless act may cause. All the hunter finds is that the insulator makes a good target for his rifle, and all the small boy knows is that a piece of bailing wire over the line will make a most interesting display of fireworks for which he does not have to wait until the Fourth of July. Whether done maliciously or carelessly, detection is difficult. A transmission line is open to attack anywhere along its entire length. This source of weakness, the liability of interruption from maliciously or carelessly inclined persons is one of no mean proportion. Usually a vigorous prosecution of the first case against which sufficient evidence can be brought to convict is the best protection.

An instance in which malicious interference became a serious problem occurred in the high-tension transmission plants which take power into the City of Mexico. In that region the favorite implements for causing shorts on the line were the leaves of the Magay plant, a sort of cactus. The leaves of this plant are very largely composed of water, and are, therefore, very good conductors of electricity, at least for the high voltages. The natives' chief delight seemed to be in throwing these leaves over the high-tension lines and watching the resultant fireworks.

On one occasion a native was caught "red-handed" in the act of throwing a Magay leaf upon one of the transmission lines. He was immediately taken before a Mexican judge and the case clearly proved against him. The judge sentenced the culprit to one year in jail, and then suspended the sentence until the next Magay leaf should be thrown upon the transmission line—no matter by whom. This practically gave this Mexican the choice of going to jail for one year or constituting himself a committee of one to patrol the line and see that no further interference occurred.

One limitation which is imposed by the human element is the use of a bad or inadequate method, but this source of trouble is practically self-eliminating. As soon as a certain method proves to be inadequate it is superseded by another which obviates the failures of its predecessor. Some methods, however, outlive their usefulness, usually because if another method is found it is difficult to convince those responsible that the new method is the better one. One of the methods of construction which, in the writer's opinion, falls under this head, is the use of rubber-insulated, lead-covered cables for conveying high-tension currents inside of buildings. The method of insulating in the open is practically standardized. The size and material of insulators, pins, cross arms, etc., are practically fixed by precedent. For insulation inside buildings, however, it has been customary in the past to place considerable, if not implicit, reliance upon the rubber of a rubber-insulated cable. The experience of the writer has been that for high-tension insulators, rubber is not reliable. His first experience came at Niagara Falls some years ago.

At the time of raising the voltage on the

Niagara-Buffalo line from 10,000 to 20,000 volts, a change in arrangements made necessary the rewiring of the high-tension circuits of the transformer stations. For this purpose there was used a wire covered with the first grade of rubber insulation. A number of tests were made on short sections, and the insulation in none of these tests broke down short of 70,000 volts. Entire reliance was placed on the insulation of the rubber and no particular pains were taken, therefore, with the mountings. These mountings were small clamp porcelains. Before the job was put into service it was given a test as a whole of 50,000 volts for ten minutes, which it stood perfectly. After one week of operating on a 20,000-volt, three-phase circuit, two breaks occurred in the rubber insulation. The normal voltage strain on this insulation was only about 13,000 volts, so that there was a factor of safety of at least five. Both the breakdowns occurred at the mountings, where, in order to get to the ground, it was necessary both to puncture the rubber and to pass over about 1 inch of porcelain surface. The breaks in the rubber insulation are almost certainly caused by some chemical action on the rubber, caused by the brush discharge from the cable. Whether it be ozone or nitric acid or anything else that is generated by this brush discharge is not material. The observed fact remains that this brush discharge causes a deterioration of the rubber of the cable more or less rapid, which destroys in time its insulating qualities. In this opinion I am confirmed not only by many instances in my own experience, but by that of many others as well.

Another instance in which practically the same action occurred was the experience in a suburban railway plant, power for which was generated at the central station and transmitted at 20,000 volts, three-phase, to a number of sub-stations. The high-tension wiring in both the central and substations was a good grade of rubber-covered wire incased in lead. In order to prevent accidents to employees it was thought best to ground the lead covering of the cables. In this case a brush discharge took place on the insulation of the cable at the point where the lead ended. In less than six months over 100 breaks occurred within three inches of the point where the lead casing of the cable ended. The cure in this case was to remove the lead entirely. Since that has been done very little trouble has been experienced.

A break-down of insulation causing either a ground or short circuit is injurious, not only causing an interruption to service at the time, but it causes electrical surges to take place in the circuit, which throw additional strains on the insulation on other parts of the circuit. Therefore, a breakdown in one part of a system may cause an over-straining of insulation in a distant part of the same system; the highest potentials will occur at the "reflecting points," and it is difficult to tell where these reflecting points are going to be. Further, these insulation strains are not confined to the high-tension side of the system.

A transformer may act to a certain extent as a condenser, and the sudden discharge of one side of this condenser may transmit to a certain extent electric surges to the other side. In the case which was just mentioned, for instance, where more than 100 break-downs occurred on rubber-covered cables, at the same time that these break-downs were occurring on the high-tension side of the circuit, considerable trouble was experienced with the apparatus on the low-tension side; instruments on the low-tension side seemed to suffer particularly. A number of breaks occurred also in the insulation of some rotary converters. Since the cause of the high-tension break-downs—the lead sheathing of the rubber-covered cable—has been removed practically no trouble has been reported from the low-tension side.

An approved method of doing inside high-tension wiring is to mount the wiring on insulators of the same character that would be used if the wiring was to be exposed to the weather. The rubber covering should be retained, but its only function is to protect employees or others in case of a casual contact with the wiring.

[The foregoing is an abstract of a paper read before the last meeting of the Electric Club of Cleveland.]

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TELEPHONE ENGINEERING.

Wire.

BY F. J. DOMMERQUE.

In this country telephone companies use copper, iron, steel and aluminum wire; abroad phosphor bronze wire is mostly used. A so-called bimetallic wire has been tried, consisting of a steel wire with copper sheathing, but it has proved to be unsatisfactory, as the copper sheathing failed by opening at the seam. Iron and steel wire must, of course, be galvanized to keep it from rusting.

As air is the best insulator known, wires on pole lines are left bare, except where trees or other obstacles make it necessary that they be insulated. In cables, aerial as well as underground, the wires must of course be insulated. In making aerial house connections, it is the rule to provide at least one of the drop wires with an insulating covering.

Copper wire is without doubt best adapted for telephone circuits; it should be hard drawn, large enough to be mechanically strong, and of good conductivity. Four sizes are ordinarily used in open-wire line work; No. 12 English or Imperial Standard gauge, having a bare diameter of 104 mils; No. 10 Brown & Sharpe gauge, with a diameter of 101.9 mils; No. 12 B. & S. gauge, with a diameter of 80.808 mils, and No. 14 B. & S. gauge, with a diameter of 64.08 mils. The cost of this wire depends upon the cost of raw copper, and therefore varies greatly. As wire is bought directly from the manufacturer or manufacturer's agent, there is not much danger of its being of inferior quality; nevertheless, the following information may be useful to the buyer or his inspector and may serve as a kind of specification. The wire must be drawn to the specified dimension throughout and should be measured by the inspector at the two ends of each piece and at not less than four other points about the same distance apart, using a micrometer for the purpose. The measurement should be made by moving the micrometer circumferentially around the wire in order to see that the diameter is up to requirements and is approximately the same in all directions; that is, that the wire is cylindrical. In the diameter measured at different points along the wire a variation of one and one-half mils either way is admissible, and a difference of one mil in two opposite diameters measured at the same point may be allowed.

To test the conductivity of the wire, a standard bridge may be used, and pieces of such length as can be easily measured, say 100 or 1000 ft., tested. The resistance should be that corresponding to a conductivity of 97 per cent, with an allowance of about 1 per cent variation; that is, the minimum should not be less than 96 per cent of the conductivity of pure copper with due allowance for the increase in resistance by the hard-drawing process. However, this value (96 per cent) should not be allowed on all the wire purchased, only now and then passing a piece not having more than 96 per cent conductivity. Table I gives the resistances per 1000 ft. of the sizes of wire used in telephone lines, measured in international ohms at 60° Fahr., and calculated for pure copper.

TABLE I.

Wire.	Ohms per 1,000 feet.
No. 12 Brit. Standard Gauge	0.9413
No. 10 Brown & Sharpe Gauge.......	0.9785
No. 12 Brown & Sharpe Gauge.......	1.552
No. 14 Brown & Sharpe Gauge	2.485

TABLE II.

Wire.	Ohms per 1,000 feet.
No. 12 Brit. Standard Gauge	0.96257
No. 10 Brown & Sharpe Gauge	1.0006
No. 12 Brown & Sharpe Gauge	1.587
No. 14 Brown & Sharpe Gauge	2.541

TABLE III.

Wire.	Ohms at 97%.	Ohms at 96%.
No. 12 Brit. Standard Gauge...	0.9922	1.0027
No. 10 B. & S. Gauge	1.0316	1.0423
No. 12 B. & S. Gauge	1.6362	1.6532
No. 14 B. & S. Gauge	2.6297	2.647

For hard-drawn copper the figures in Table I must be multiplied by 1.0226, which gives the values in Table II. And allowing for 97 per cent conductivity and the variation of 1 per cent the values would be as given in Table III.

Wire cannot always be measured at 60° Fahr.; therefore, if the measurement is made at some other temperature, assuming, however, that the wire has been laying in the place long enough to have the same temperature as the surrounding air, a further correction must be applied to the figures already given. The formula used for making such corrections is

$$r = \frac{R\ [1 + .00225\ (t - 32)]}{1 + .0225\ (T - 32)}$$

in which R equals the known resistance, r the unknown resistance, T the temperature for R, in Fahrenheit degrees, and t the temperature for r in Fahrenheit degrees. By means of this formula, which is an approximate one, it is easy to deduce a set of coefficients so that the resistance found at a certain temperature can be calculated for any other temperature by first dividing the coefficient for the temperature at which the resistance was measured so as to reduce to 32°, and then multiplying by the corresponding coefficient for the temperature at which the resistance is required. These are given in Table IV.

These values, however, are only approximate, as the above formula is an abridged form of the correct equation:

$$r = \frac{R\,[1+A(t-32)+B(t-32)^2]}{1+A\,(T-32)+B\,(T-32)^2}$$

but the coefficient, B, is so small that in practical work it may be neglected.

TABLE IV.

TEMPERATURE COEFFICIENTS.

Degrees Fahrenheit.	Temperature coefficient.	Degrees Fahrenheit.	Temperature coefficient.
32	1	54	1.0495
33	1.00225	55	1.05175
34	1.00450	56	1.054
35	1.00675	57	1.05625
36	1.009	58	1.0585
37	1.01125	59	1.067075
38	1.01350	60	1.063
39	1.01575	61	1.06525
40	1.01800	62	1.0675
41	1.02025	63	1.06975
42	1.02250	64	1.072
43	1.02475	65	1.07425
44	1.027	66	1.0765
45	1.02925	67	1.07875
46	1.03150	68	1.081
47	1.03375	69	1.08325
48	1.036	70	1.0855
49	1.03825	71	1.08775
50	1.0405	72	1.09
51	1.04275	73	1.09225
52	1.045	74	1.0945
53	1.04725	75	1.09675

The method of using the table is illustrated by the following example: Assuming the measurement were made for a No. 12 B. & S. wire having a temperature of 40° Fahr., and it was found that the resistance was 1.56 ohms per 1000 ft.; find in the table the coefficient corresponding to 40°, which is 1.018; divide 1.56 by 1.018, which gives 1.5324; multiply this by the coefficient corresponding to 60°: $1.5324 \times 1.063 = 1.6389$ ohms, which is inside the requirements.

The next point to be looked out for is that the proper weight is obtained. In order to facilitate weighing, the manufacturer should be required to deliver the wire in coils, each containing one continuous piece of wire without braces or joints or splices of any description, the eye of the coil to be not less than 18 ins. and not more than 20 ins. in diameter. If copper wire is bought in large quantities it would be better for the inspector to go to the factory for testing, as the tests for torsion and elongation, to be described later on, cannot well be made elsewhere; also, if he goes to the factory he can weigh the wire before it is packed. If, however, the wire is weighed upon delivery, the wrapping must be taken off or allowed for. The weight per thousand feet should be as given in Table V.

The manufacturer should be required to stamp the weight of each coil upon two brass tags, which must be firmly attached to the coil, one inside the wrapping and the other outside. If it is impracticable to weigh all the wire, at least 2 per cent of the total should be weighed. Each coil should be made up of enough wire to have a weight between the limits given in Table VI. It must not be forgotten when estimating the cost of a plant that more than 5280 ft. of wire to the mile are required on account of sag between poles, connections, etc., and that this must be allowed for in determining the weight.

TABLE V.

	Required per 1000 ft. lbs.	Maximum per 1000 ft. lbs.	Minimum per 1000 ft. lbs.
No. 12 Brit. Standard Gauge	32.84	33.41	32.27
No. 10 B. & S. Gauge	31,82	31.82	30.68
No. 12 B. & S. Gauge	19.43	20	19.09
No. 14 B. & S. Gauge	12.31	12.80	11.93

The next item in the requirements is the mechanical properties of the wire, and relates to its strength. Three tests are to be made in this connection, a tension test, an elongation test and a torsion test. To make a tension test, a machine is required; and since such a machine is an expensive piece of apparatus, as a rule only the manufacturer is in a position to own one. A sample piece 18 ins. long is put into the machine and subjected to a tension until it breaks. The loads specified in Table VII should be required to break telephone wire. The elongation test is made in the same machine. The wire should stand elongation as follows: No. 12 British Standard gauge, 1 per cent in 5 feet; No. 10 B. & S. gauge, 0.99 per cent; No. 12 B. & S. gauge, 0.94 per cent., and No. 14 B. & S. gauge, 0.91 per cent in 5 feet.

TABLE VI.

	Max. lbs.	Min. lbs.
No. 12 Brit. Standard Gauge....	219	151
No. 10 B. & S. Gague	218	152
No. 12 B. & S. Gauge	72	52
No. 14 B. & S. Gauge	...	40

The torsion test is made in a torsion testing machine. A piece 12 ins. long is placed between the jaws of the machine, one of which is made to revolve until the wire is twisted in two; the number of twists a 6-in. piece of wire should stand is as follows: No. 12 British Standard gauge and No. 10 B. & S. gauge, 40 twists; No. 12 B. & S. gauge, 44, and No. 14 B. & S. gauge, 47 twists.

TABLE VII.

	Actual required breaking weight.	Actual minimum breaking weight.	Breaking weight per sq. inch.
	lbs.	lbs.	lbs.
No. 12 Brit. Stand. Gauge	549	538	64600
No. 10 B. & S. Gauge	540	519	64800
No. 12 B. & S. Gauge	334	327	66500
No. 14 B. & S. Gauge	220	212	68200

Finally, all wire must be free from scale, flaws, splits, seams, cold shuts, and such other defects as may be detrimental to it.

Notwithstanding the fact that the three kinds of iron wire used for telephone lines are designated by the well-sounding names, "Extra Best Best" (usually written E. B. B.), "Best Best" (B. B.) and "Best" (B.), there is not much chance left for iron wire in line construction except for house connections, and in that case No. 14 insulated iron wire is used. Considering the fact that in modern work open-wire lines are almost entirely restricted to distribution lines, it would hardly pay to substitute iron for copper, as it is upon just these short lines that the greatest amount of labor is charged on account of the connection to distributing poles or cable boxes, and it would be poor economy to use in such cases a kind of wire that would require frequent renewals. In long lines, however, where the quality of service is of secondary importance, and where practically no long-distance connections are required, as for instance in farmers' lines, iron may find a place on account of its cheapness. If anybody wants to use iron wire, the writer would recommend either the E. B. B. or else steel wire.

The conductivity of iron wire is from one-fifth to one-ninth that of copper; the conductivity of steel is from one-ninth to one-twenty-eighth that of copper. As stated before, the breaking weight or ultimate strength of copper telephone wire (No. 12 British Standard to No. 14 B. & S.) varies from 64,600 pounds per square inch to 68,200 pounds per square inch; the breaking weight of iron telephone wire varies from 53,100 to 65,490 pounds per square inch, and of steel wire from 50,000 to over 300,000 pounds per square inch.

In late years a number of important power transmission plants in the West have used aluminum conductors, and this circumstance has induced some of the telephone people, also in the West, to try aluminum wire on telephone lines, so that a few remarks in regard to the use of aluminum wire will not be out of place. Aluminum is a metal possessing a great lustre and is affected very little by impurities in the air that would be injurious to copper, as for instance the acids in smoke and soot. It is a very light metal and weighs about .3 as much as copper. Its conductivity is about 60 per cent that of copper. Thus, the conductivity of a No. 10 B. & S. copper wire is approximately the same as that of a No. 8 aluminum wire, which weighs 15 pounds per 1000 feet. The cross-section of a No. 10 B. & S. copper wire being 10,404 circular mils, the cross-section of an aluminum wire of the same conductivity would, then, be

$$\frac{10404 \times 100}{60} = 17{,}340 \text{ circular mils;}$$

hence, the No. 8 aluminum wire, the cross-section of which is only 16,384 circular mils, has too small a cross-section, but it is the nearest gauge number to the size required to give a resistance equal to that of a No. 10 copper wire. The cross-section of a No. 12 B. & S. copper wire is 6561 circular mils; therefore, the corresponding cross-section of an aluminum wire would have to be $\frac{6561 \times 100}{60} = 10{,}935$ circular mils. Now the cross-section of a No. 10 aluminum wire is 10,404; hence, a No. 10 B. & S. aluminum wire corresponds very closely to a No. 12 B. & S. copper wire. One thousand feet of No. 10 B. & S. aluminum wire weighs 9.5 pounds.

The cross-section of a No. 14 B. & S. copper wire is 4096 circular mils; the corresponding cross-section of an aluminum wire would have to be $\frac{4096 \times 100}{60} = 6827$ circular mils, the nearest B. & S. gauge being No. 12, which is 6561 circular mils. One thousand feet of B. & S. aluminum wire weighs 6 pounds. From the foregoing calculations it is evident that for all practical purposes the difference in conductivity between copper and aluminum wire is two gauge numbers, aluminum being the larger, of course.

It would seem feasible to set the poles farther apart when using aluminum wire, since for the same conductivity the weight of the aluminum wire is less than that of the copper wire; but it must be remembered that the aluminum wire presents a much greater surface to the wind, and in winter may accumulate an enormous amount of sleet; so on the whole, there is not much chance to save in that direction. However, on power transmission lines using aluminum conductors, poles have been set as far apart as 132 feet, but that was in California, where climatic conditions are more favorable than in the eastern and central states; aluminum is more suitable for use in a warm climate than in a cold or variable one.

Aluminum wire has an ultimate tensile strength of 22,700 pounds per square inch, and with regard to strength in a span is equivalent to a copper wire of about 70,000 pounds tensile strength per square inch. There is no trouble in joining aluminum wires, as sleeve joints are made for that purpose similar to the McIntyre or American copper wire sleeve. The price of aluminum is higher than the price of copper. At 33 cents per pound, aluminum could compete with copper at 16 cents per pound. The cost of stringing is about the same for copper and aluminum.

The wires are held to the insulators by soft copper tie wires, which are about 16 ins. long, and may be a size or two smaller than the line wire, though as a rule they are of the same size. The amount of tie wire required for 1000 feet of line wire is about as follows: For No. 12 British Standard gauge, 0.43 pound; for No. 10 B. & S. gauge, 0.42 pound; for No. 12 B. & S. gauge, 0.26 pound, and for No. 14 B. & S. gauge, 0.17 pound. For each mile of wire in place, counting 5400 feet to the mile, there are required about 2.32 pounds for No. 12 British Standard gauge; 2.27 pounds for No. 10 B. & S. gauge; 1.40 for No. 12 B. & S. gauge, and 0.92 pound for No. 14 B. & S. gauge. The cost of tie wire is about 5 per cent higher than that of line wire.

The two joints most used in telephone work are the McIntyre and the American, both of which are designed on the same principle. In the McIntyre joint a double tube of copper is drawn in one piece; this tube or sleeve is four inches long and fits the wire to be spliced. The ends of the wire are pushed through the tubes in opposite directions and are then grapsed at each end with a special splicing tool and given three complete twists.

The American sleeve is the same as the McIntyre, except that the two tubes are formed by a thin sheet of copper which is rolled in opposite directions from the middle, each tube consisting of three layers of copper. Both kinds of sleeves are good, and strong enough to hold the wires firmly together. In small quantities the American sleeves cost $95 per 1000 and the McIntyre $140 per 1000; 50 per cent discount is given in large quantities. The tools for twisting, splicing clamps or pliers, cost $1.35 to $1.80 each. The average number of joints required per mile of wire, allowing 5400 feet to the wire mile in place, is four.

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MECHANICAL DRAFT.

BY CHARLES L. HUBBARD.

Mechanical draft may be used either as a substitute for a tall chimney or for increasing the power of a chimney already in use. With mechanical draft the boilers may be run at their maximum capacity without regard to outside weather conditions, and as the draft is independent of the temperature of the chimney gases it allows of their being cooled to a comparatively low degree, thus making available a certain quantity of heat which may be utilized in an economizer, for example. A saving of 10 per cent or more in fuel is often accomplished in this way. Another advantage is that poorer grades of fuel may be used than is possible with a natural draft.

According to Mr. Alfred Blechyden, the capacity of a boiler may be increased from 30 to 40 per cent for continuous working, and much more for short runs, by the use of mechanical draft. This feature is especially welcome in the case of electric light and power stations where the maximum quantity of steam is required for only a few hours per day. Of course, forcing a boiler beyond a certain limit lowers its rate of evaporation per pound of coal, but for short runs this is often more than offset by the reduced first cost of the plant and the smaller operating expenses. Ease of regulation is another advantage of considerable importance.

The rate of combustion varies with the intensity of the draft, and in ordinary heating and power work usually ranges from about 15 to 30 pounds of coal per hour per square foot of grate surface. In marine and locomotive boilers it is much higher, varying from 30 to 50 pounds in the former and from 60 to 125 in the latter. If the rate of combustion be increased in the case of a boiler steaming at maximum efficiency with natural draft, while the grate surface remains unchanged, the rate of evaporation per pound of coal will be reduced; but if the grate area be reduced so that with a higher rate of combustion per unit of surface the total quantity of fuel burned per hour remains unchanged, a certain increase in efficiency will be obtainable. This is due principally to the deeper fire, which may be varied with a forced draft, thus causing the air to come in contact with a greater amount of fuel and affording a better opportunity for more perfect combustion. This reduces the quantity of air required, produces a hotter fire and radiates more heat to the boiler surfaces.

Experience has shown that under ordinary conditions a combustion of about 0.3 of a pound of coal per square foot of boiler heating surface seems to give the most satisfactory results. This should be borne in mind as a guide when applying forced draft to a boiler. As the rate of combustion is increased the total amount of coal consumed should be kept approximately the same by reducing the size of grate, as indicated above. Assuming 15 square feet of heating surface per horse-power for tubular boilers, and 10 feet for water-tube boilers, the grate areas per horse-power for higher rates of combustion will be as given in Table I.

TABLE I.

Pounds of coal burned per sq. ft. of grate per hour.	Square feet of grate per horse-power.	
	Tubular Boilers.	Water-tube Boilers.
15	0.30	0.22
18	0.25	0.19
21	0.22	0.16
24	0.20	0.14
27	0.17	0.12
30	0.15	0.11

There are three systems of mechanical draft commonly applied to stationary boilers: The steam jet, by means of which steam and air are blown into the ash pit; forced draft, or the closed ash pit system, in which a fan is employed to discharge air under pressure into the ash pit; and induced draft, obtained by means of an exhaust fan placed in the smoke flue to produce suction. In the last-mentioned arrangement the gases pass through the fan and are discharged into the chimney or up-take.

The steam jet system is usually the most wasteful method of producing a draft, but it has certain advantages, including the burning of cheap coals high in ash, and the decomposition of the steam into hydrogen and oxygen in the bed of hot coal, which tends to prevent the formation of clinkers. The expense of running a steam jet is the cost of the steam used and that of the heat required to superheat it to the temperature of the chimney gases. A series of tests made at the New York Navy Yard some years ago showed the amount of steam required to vary from 8 to 20 per cent of the total steam generated by the boiler. The percentage required is found to be larger as the size of the plant diminishes. The simplicity and low first cost of the steam jet are among its advantages.

Fig. 1 shows the Argand blower, a form of steam jet commonly used with the McClave grate. It is connected with the ash pit, as shown in Fig. 2, and delivers a large volume of air mixed with steam beneath the grate. The steam is discharged through a large number of small openings in a metal ring and the air is drawn into the surrounding nozzle by the strong suction produced.

The forced draft or blower system is the one most easily applied to existing plants when it is desired to increase the draft for burning cheaper grades of fuel. The air is usually introduced through openings in the bridge wall or in the bottom of the ash pit. Care should be taken to distribute the air supply as evenly as possible in order to prevent holes being blown through the fire. This may be accomplished by the use of deflecting dampers, which throw the air downward as it enters the ash pit. Arrangements of dampers used by the Sturtevant Company for this purpose are shown in Figs. 3 and 4. The pressure within the ash pit and furnace tends to blow ashes and flame into the fire room if forced too hard, but under a moderate draft little trouble will be experienced from this cause. Care should always be taken to close the damper in the blast pipe before opening the furnace or ash pit doors.

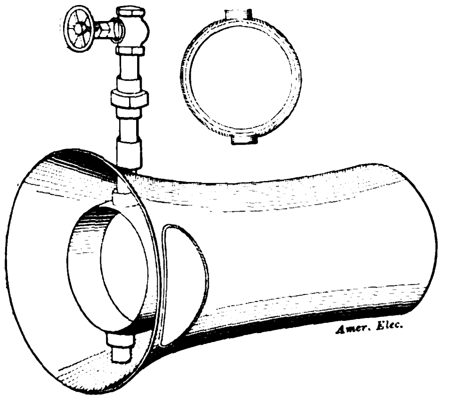

FIG. 1.—ARGAND BLOWER.

With the induced draft system, a partial vacuum is produced within the furnace and its effect is, therefore, practically the same as that of a chimney. It is more easily controlled than other systems, and as the leakage is inward all inconvenience from flame and dust blowing out at the fire doors is avoided. A specially-constructed fan, with reliable means for keeping the bearings cool, is required for this system, as the temperature of the gases passing through it range from 300° to 500° Fahr., or even more. Fig. 5 shows in a general way the method of connecting the fan with the smoke pipe and chimney. The arrangement is, of course, varied to suit different conditions.

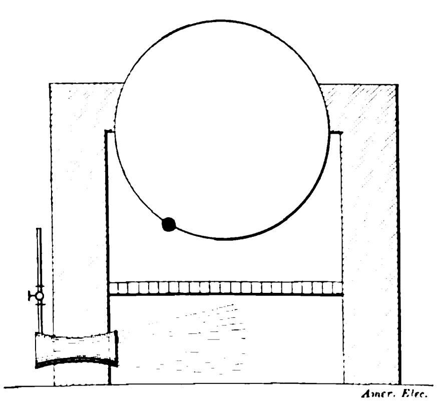

FIG. 2.—APPLICATION OF ARGAND BLOWER.

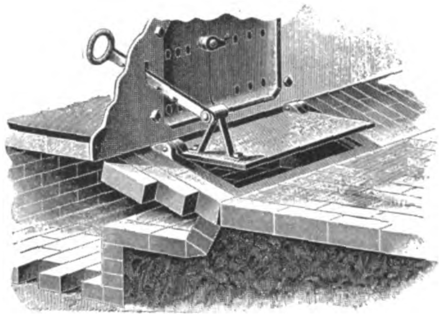

FIG. 3.—ASHPIT DAMPER IN BOTTOM OF ASHPIT

Theoretically, about 12 pounds of air are required to burn 1 pound of average coal or coke. In practice, however, with natural draft, it is necessary to supply about twice this amount to secure complete combustion, owing to the difficulty of bringing the air into contact with the entire body of coal. With forced draft and deeper fires, the quantity of air supplied may be reduced to about 18 pounds per pound of coal, which is equivalent in round numbers to 225 cubic feet. This reduction should, theoretically, increase the efficiency of the boiler about 10 per cent. The draft required will vary in different cases according to the fuel used, the size and length of smoke passages, etc. In ordinary practice the draft usually varies from 1 to 2½ ins. of water in the case of stationary boilers.

TABLE II.

Diameter of fan.	Pressure.														
	0.9 inch			1.3 inches			1.7 inches			2.1 inches			2.5 inches.		
	Rev.	Cu.ft.	H.P.	Rev.	Cu.ft.	H.P.	Rev.	Cu.ft.	H.P.	Rev.	Cu.ft.	H.P.	Rev.	Cu.ft.	H.P.
18 ins.	770	900	½	950	1100	½	1100	1300	1	1200	1400	1½	1350	1600	1½
24 ins.	580	1600	¾	700	1900	1	820	2200	1½	920	2500	2	1000	2800	1½
30 ins.	460	2600	1	570	3200	1½	660	3700	2½	740	4100	3	800	4500	4½
36 ins.	380	3700	1¼	470	4600	2	550	5300	3½	600	5900	4½	670	6500	6
42 ins.	330	5900	2	400	7300	3½	470	8400	5½	530	9400	7½	570	10300	9½
48 ins.	290	7600	2½	360	9300	4½	400	10800	6½	460	12000	9	500	13200	12
54 ins.	260	10000	3½	320	12700	6	370	14700	9	400	16400	12	450	18000	16
60 ins.	230	12300	4	280	15000	7	330	17400	11	370	19500	15	400	21400	20
72 ins.	190	21500	7	240	26300	12	270	30400	18	300	34000	26	340	37000	35

Table II gives approximately the size and speed of fan, quantity of air delivered and power required for producing different pressures of mechanical draft. These figures are for average conditions, with the usual form of steel plate blower or exhauster. The diameter of fan is in inches, speed in revolutions per minute, and delivery in cubic feet per minute. It is customary to use a steam engine for running the fan, so it is an easy matter to change the speed to produce the desired result in any particular case. Regulation is usually obtained by means of a throttle valve controlling the supply of steam to the blower engine and operated automatically by the pressure in the boiler so as to change the speed of the fan to meet the requirements of the boiler furnace.

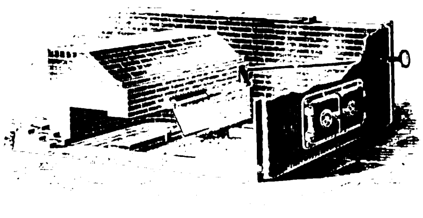

FIG. 4.—ASHPIT DAMPER IN BRIDGE WALL.

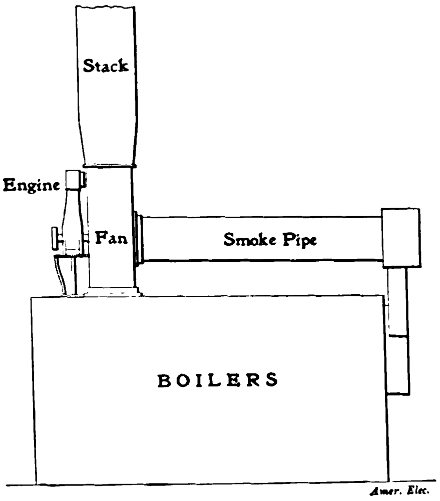

FIG. 5.—INDUCED DRAFT.

Knowing the total quantity of coal to be burned per hour, and assuming the probable draft pressure required, the proper size of fan and engine can at once be taken from the table. In the case of induced draft the quantity of air to be handled by the fan is increased, due to its higher temperature and the resulting expansion. Table III gives the relative volume of a given weight of air at temperatures from 50° to 600°. The temperature of the chimney gases commonly ranges from 400° to 600°, unless the gases are passed through an economizer, in which case they are cooled from 200° to 300°. From the data given, the size of fan for an induced draft system can be determined approximately as follows: Find the volume of air required for combustion as before, and multiply it by the ratio given in column 2 or 4 of Table III opposite the assumed temperature of

TABLE III.

Temperature Deg. Fahr.	Volume for same weight.	Temperature Deg. Fahr.	Volume for same weight.
50	1.00	350	1.60
100	1.10	400	1.68
150	1.20	450	1.78
200	1.30	500	1.88
250	1.40	550	1.98
300	1.50	600	2.08

the flue gases; then take from Table II the size and speed of fan to discharge this volume of air at the required pressure.

Builders of mechanical draft apparatus usually furnish an engine of standard size with each fan, of sufficient power to drive it at its probable maximum speed under the conditions of each special case.

Tests of a Belgian Engine Using Superheated Steam

In view of the growing interest in the use of superheated steam in engines, and the advances that have been made in the application of superheat, a series of tests made on a Van den Kerchove (Ghent, Belgium) engine recently by Prof. M. Schroeter, of Munich, should be of considerable interest. The engine was a horizontal tandem compound machine rated at 250 horse-power, and the tests were made with it driving a direct-current dynamo, the armature of which was mounted directly on the engine shaft. The cylinders of the engine were 12.8 ins. and 22.05 ins. in diameter, and the stroke 33.47 ins., so that the cylinder ratio was 1:3. The rated speed was 127 r.p.m. The heads of the two cylinders were jacketed, that of the high-pressure cylinder containing live steam, while that of the low-pressure cylinder took steam from the receiver; steam was delivered from the jackets to the cylinders. The distribution of steam was taken care of by four balanced piston-valves, operated by eccentrics on a secondary shaft running parallel to the axis of the cylinder. The condenser was placed beneath the engine, and a vertical air-pump was driven from the crank-pin of the engine. During the tests the dynamo was loaded by means of a water rheostat.

The object of the tests was to make a great number of careful observations under different conditions, from no load to full load, for the purpose of studying the behavior of the engine with saturated steam and steam superheated to 572° Fahr. with the greatest variation possible in the period of admission, and also the steam consumption with different degrees of superheating and a constant period of admission. The steam consumption per indicated horsepower was taken as the measure of economy, because a determination of the coal consumption would have increased the number of detailed observations to an impracticable extent, and moreover, there was no desire to ascertain the boiler and furnace efficiency. A surface condenser was used, and the water of condensation measured. By this method it was possible to obtain a quick determination of the steam consumption, and also to measure accurately the condensed jacket steam, which was not allowed to enter the cylinders. The water of condensation was handled by two pumps driven from the same point, one of which provided the circulation and the other delivered the water to a large tank placed on scales.

In order to obtain enough readings and cards to give good mean values, each test was made to last about an hour. During each test the water of condensation from the two jackets, which was delivered by automatic valves, was carefully measured by means of a graduated vessel.

The superheater used was of the direct type, entirely separate from the boiler; and on account of its being independent, it was possible to obtain in the high-pressure cylinder all periods of admission from no load to maximum with the same temperature of the steam. Under ordinary circumstances, using superheaters placed in the flues of the stack, the amount of superheating increases largely as the load diminishes.

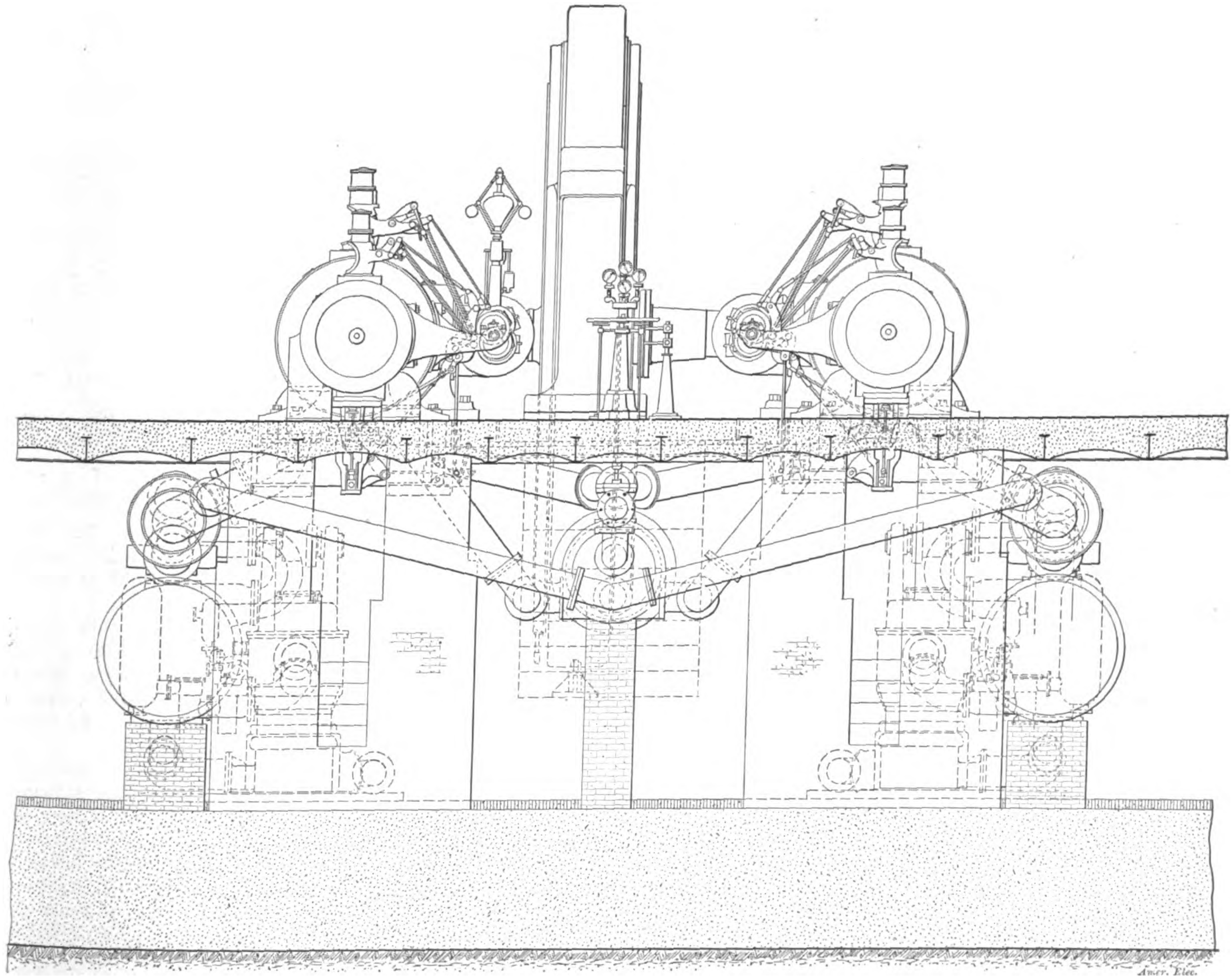

FIG. 1.—END ELEVATION OF A 2000-H.P. VAN DEN KERCHOVE ENGINE USING SUPERHEATED STEAM.

The tests were subdivided into two groups, as follows: (1) A comparison of the consumption of saturated steam with that obtained with a constant superheating of 256° Fahr. for various loads. (2) Observations of the influence of a progressive temperature of superheating with a constant load on the engine. The last test of the first group, with a steam temperature of 662° Fahr., was made in the same manner as the first one, but later on; the reason for which was that it was necessary to make a slight modification of the distribution in the high-pressure cylinder, as it was not intended originally for such high temperatures, and time was not available for making the change when the other tests were made. However, the results of this test accord perfectly with the others. No trouble in operation was experienced during any of the tests that were made; on the contrary, the ease and reliability of operation, even with the greatest amount of superheating, are said to have been most gratifying.

In Table I are included the constants of the engine. A temperature of 59° Fahr. was taken as the standard, and the values given correspond; in determining the increase in cylinder diameters due to expansion the numbers in Table II were adopted as mean values of the temperatures of the iron. However, the effect of temperature was so slight, as may be seen by a reference to the table, that a more exact determination of the mean temperature was unnecessary. The indicator springs were carefully calibrated in the testing-room of the engineering laboratory of the Polytechnic School, at Munich. For the spring that was to be used for the large cylinder, due consideration was given to the fact that it was to be used for pressures below as well as above the atmospheric line. The calibration was made with saturated steam, which experience has proven to be admissible for indicator springs that are to be used with superheated steam. The results of these tests are in accordance with the well-known fact that light springs have a different rate for extension and compression—that is, for points above and below the atmospheric line.

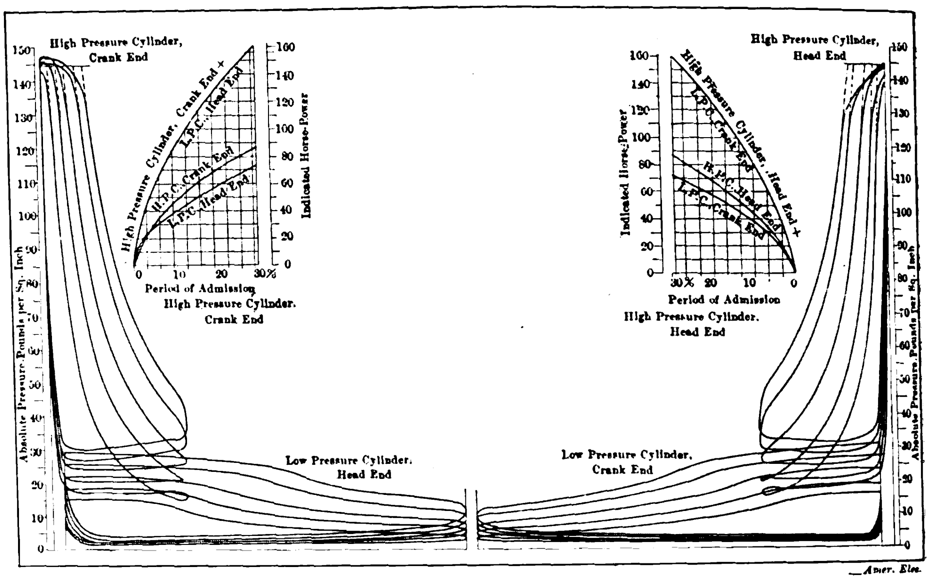

FIG. 3.—DIAGRAMS FROM ENGINE USING SATURATED STEAM.

TABLE I.

	Saturated Steam		High Pressure Cylinder.				Superheated Steam						Low Pressure Cylinder	
	Crank end.	Head end.	Crank end.	Head end.	Crank end.	Head end.	Crank end.	Head end.	Crank end.	Head end.	Crank end.	Head end.	Crank end.	Head end.
Temperature of steam at admission, F	356°		392°		446°		500°		572°		662°		176°	
Mean temperature of cylinder walls..	302°		347°		383°		410°		437°		464°			
Number of test........................	I. to VI.		XII.		XIII.		XIV.		VII. to XI. & XV.		XVI.		I. to XVI.	
Diameter of cylinders, ins............	12.818		12.821		12.823		12.826		12.827		12.829		22.069	
Area of cylinders, sq. ins............	128.93		129.04		129.10		129.11		129.12		129.16		382.11	
Diameter of piston-rods, ins..........	2.36	0	2.36	0	2.36	0	2.36	0	2.36	0	2.36	0	2.91	2.36
Area of piston-rods, sq. ins..........	4.38	0	4.38	0	4.38	0	4.38	0	4.38	0	4.38	0	6.65	4.38
Effective area of pistons, sq. ins.. ..	124.55	128.93	124.66	129.04	124.72	129.10	124.73	129.11	124.74	129.12	124.78	129.16	375.46	377.83
Stroke, ins...........................	33.47													
Mean ratio of cylinders...............	1:2.97													

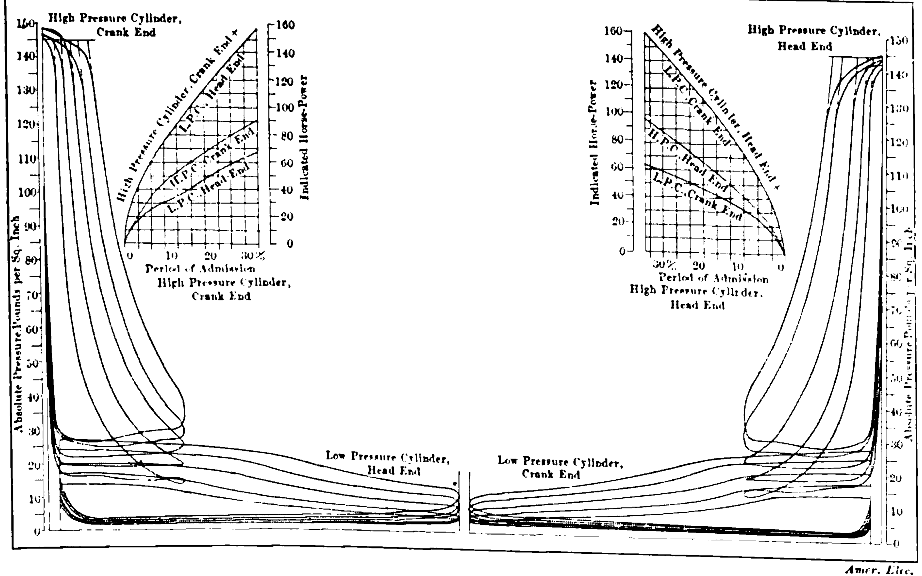

FIG. 2.—DIAGRAMS FROM ENGINE USING SUPERHEATED STEAM.

In Table II are given the results of planimetering all the cards, the indicated powers, and other data; these figures are mean values of observations taken every five minutes. The main results obtained in regard to the consumption of steam and heat used per indicated horse-power per hour are collected for recapitulation in Table III.

Since the test of 5½ hours duration (No. XV) gave substantially the same results as one which lasted only 50 minutes (No. IX), Professor Schroeter draws the conclusion that accurate results may be obtained from tests of only an hour's duration. It might have been possible to get accurate results with tests of even shorter duration, except for the fact that the intermittent action of the automatic valves delivering condensed steam from the jackets would doubtless have vitiated the results.

TABLE II.

Number of Test.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
Revolutions per minute	126.0	126.1	126.4	126.9	137.7	129.0	126.0	126.1	126.4	126.9	127.7	126.6	126.6	126.6	126.6	126.9
High pressure cylinder Crank end Mean effective pressure	63.4	56.3	46.4	35.2	21.5	2.9	67.2	51.2	49.8	38.9	26.0	44.4	44.8	45.5	46.4	46.4
High pressure cylinder Crank end Indicated horse-power	84.1	74.7	61.5	46.9	28.8	3.96	89.2	74.6	66.3	52.2	34.9	59.0	59.8	60.8	61.8	62.4
High pressure cylinder Head end Mean effective pressure	59.8	51.8	40.4	30.7	21.9	3.1	67.1	57.6	44.4	31.9	22.5	42.2	44.1	44.1	46.4	45.3
High pressure cylinder Head end Indicated horse-power	82.2	71.1	55.6	42.5	30.5	4.28	92.4	79.4	61.2	44.1	31.4	58.2	60.8	60.9	64.0	62.6
Total indicated horse-power. High pressure cylinder	166.3	145.8	117.1	89.4	59.3	8.24	181.6	154.0	127.5	96.3	66.3	117.2	120.6	121.7	125.8	125.0
Low pressure cylinder Crank end Mean effective pressure	17.6	15.2	12.3	9.4	6.9	1.6	15.6	13.6	10.9	8.5	6.2	12.7	12.4	11.8	11.2	10.6
Low pressure cylinder Crank end Indicated horse-power	70.5	60.8	49.5	37.9	28.1	6.58	62.6	54.8	43.9	34.3	25.2	51.2	49.9	47.5	45.2	42.6
Low pressure cylinder Head end Mean effective pressure	17.6	15.5	12.2	9.4	6.8	1.5	16.4	13.9	11.3	8.6	6.4	12.7	12.4	11.9	11.1	10.9
Low pressure cylinder Head end Indicated horse-power	71.0	62.4	49.4	38.0	27.7	6.39	65.8	56.2	45.7	34.7	26.2	51.4	50.3	48.8	45.6	44.5
Total indicated horse-power. Low pressure cylinder	141.5	123.2	98.9	75.9	55.8	12.97	128.4	111.0	89.6	69.0	51.4	102.6	101.2	95.6	90.8	87.1
Total indicated horse-power of engine	307.8	269.0	216.0	165.3	115.1	21.21	310.0	265.0	217.1	165.3	117.7	219.8	221.8	217.3	216.6	212.1
Current in amperes at 110 volts	1730	1500	1200	900	600	No load	1730	1500	1200	900	600	1200	1200	1200	1200	1200
Number of indicator cards	13	13	13	12	12	8	11	13	10	13	11	10	10	9	24	4
Indicated horse-power at 127.5 r.p.m.	314.5	272.2	217.9	166.1	115.0	20.95	313.8	268.0	219.2	166.0	117.6	....	....	....	....	....
Mean effective pressure reduced to the low pressure cylinder	38.4	33.6	26.9	20.5	14.2	2.57	38.7	33.0	27.0	20.5	14.5	17.4	17.3	16.9	16.7	16.3
Atmospheric pressure	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.65	14.8	14.8	14.8	14.65	14.65	14.65	14.65	....
Inches of vacuum in condenser	27.6	27.7	27.9	27.9	27.8	No load	27.6	27.7	27.9	27.9	27.8	27.7	27.8	27.8	....	27.8
Absolute pressure in condenser	1.28	1.14	1.14	1.14	1.14	No load	1.28	0.996	1.14	1.14	1.14	0.996	0.996	0.996	....	....
Absolute back pressure in low pressure cylinder at half stroke	4.07	3.30	2.79	2.47	2.09	No load	3.65	3.07	2.70	2.33	2.03	2.72	2.69	2.62	2.88	....
Vacuum in Condenser, ...%	91	92	92	92	92	No load	91	93	92	92	92	93	93	93	....	....
Vacuum in Low pressure cylinder, ...%	72.5	77.7	81.2	83.3	85.9	No load	75.3	79.0	81.7	84.3	86.3	81.5	81.7	82.1	80.3	....
Absolute pressure of steam at admission in high pressure cylinder	148.4	146.2	146.9	141.5	142.2	145.0	147.5	148.4	148.9	145.6	146.5	145.6	143.5	144.4	146.6	146.2
Temperature of saturated steam corresponding to pressure at admission in high pressure cylinder	357.3	356.2	356.5	353.7	354.0	355.5	356.9	357.2	357.6	355.8	356.4	355.8	354.7	355.3	356.4	356.2
Temperature of steam at admission in high pressure cylinder	357.3	356.2	356.5	353.7	354.0	355.5	603.3	614.4	615.5	611.7	612.3	431.7	484.4	539.0	609.6	699.1
Degrees of superheating above temperature of saturation	....	....	....	....	....	....	246.4	257.2	257.9	255.9	255.9	75.9	129.7	183.7	253.2	342.9
Total number of B. T. U. at saturation	2625	2624	2625	2620	2621	2624	2625	2625	2626	2624	2625	2624	2622	2624	2625	2624
Total B. T. U. in the steam at admission	2625	2624	2625	2620	2621	2624	2851	2863	2864	2860	2861	2671	2724	2784	2859	2953

TABLE III.

Number of Test.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.
Indicated horse-power of engine	307.8	269.0	216.0	165.3	115.1	21.21	310.0	265.0	217.1	155.3	117.7	219.8	221.8	217.3	216.5	212.1
Length of test, mins.	60.16	61.04	57.54	54.96	50.34	53.23	48.15	59.69	50.82	64.66	54.96	73.70	58.05	47.61	337.54	57.18
Steam per hour by surface condenser	3740	3035	2300	1685	1182	248.5	3299	2661	2082	1424	1082	2332	2279	2222 }	1212	1850
Condensed steam per hour from high pressure cylinder jacket	77.6	89.8	92.0	97.3	99.4	32.4	7.7	6.8	6.6	6.2	6.6	6.2	6.2	5.7 }		7.5
Condensed steam per hour from low pressure cylinder jacket	378.3	317.7	249.5	170.5	99.4	10.0	62.9	89.4	76.2	65.0	45.7	241.3	175.8	120.8 }		48.6
Condensed steam per hour from both jackets	455.9	407.5	341.5	267.8	198.8	42.4	70.6	96.2	82.8	71.2	52.3	247.5	182.0	126.5	....	56.1
Total steam per hour	4196	3443	2642	1953	1381	290.9	3370	2757	2165	1495	1134	2580	2461	2349	2155	1906
Condensation in high pressure cylinder jacket in per cent. of total steam consumption	1.86	2.61	3.48	4.98	7.20	11.10	0.23	0.25	0.31	0.38	0.58	0.24	0.25	0.24	....	0.39
Condensation in low pressure cylinder jacket in per cent. of total steam consumption	9.00	9.23	9.45	8.72	7.20	3.41	1.87	3.24	3.51	4.05	4.02	9.34	7.15	5.14	....	2.54
Total jacket condensation in per cent. of total steam consumption	10.86	11.84	12.93	13.70	14.40	14.51	2.10	3.49	3.82	4.43	4.60	9.58	7.40	5.38	....	2.93
Steam consumption per indicated horse-power per hour	13.63	12.79	12.23	11.82	12.00	13.70	10.87	10.40	9.98	9.63	9.62	11.74	11.18	10.75	9.96	8.99
Temperature of steam at admission	357.3°	356.2°	356.5°	353.7°	354.0°	....	603.3°	614.4°	615.5°	611.7°	612.3°	431.7°	484.4°	539.0°	609.6°	699.1°
Temperature of condensed steam	88.9°	83.7°	76.8°	75.4°	74.8°	No load	87.6°	80.4°	76.5°	75.9°	75.9°	78.1°	77.0°	77.0°	....	73.9°
Initial temperature of cooling water	68.4°	69.3°	69.6°	69.3°	68.0°	No load	68.2°	68.0°	68.9°	70.0°	70.0°	68.4°	68.0°	68.2°	....	64.4°
Final temperature of cooling water	90.7°	87.8°	82.6°	78.8°	76.3°	No load	90.3°	86.0°	82.4°	79.3°	76.6°	84.6°	84.2°	82.8°	....	80.6°
Equivalent consumption of saturated steam per horse-power per hour	....	....	....	....	....	No load	11.82	11.35	10.89	10.59	10.51	11.95	11.60	11.49	10.86	10.09
Gain due to superheating in per cent. of consumption of saturated steam	....	....	....	....	....	No load	13.3	12.1	11.0	10.4	12.5	2.4	5.1	6.0	11.3	17.3
B. T. U. per indicated horse-power per hour	1573	1477	1414	1365	1387	1585	1366	1313	1260	1224	1215	1383	1343	1327	1263	1170

The results of all the tests are shown graphically in Figs. 2 and 3; the combined cards showing clearly the distribution of the steam. In order to make a comparison of the periods of admission, the cards from the high-pressure cylinder have been carried up at the top to a pressure of 145 lbs. per square inch. The distribution of power in the two cylinders is likewise graphically indicated. The mean values of periods of admission corresponding to the initial pressure in the high-pressure cylinder are plotted as abscissas, and indicated powers for the same number of revolutions as ordinates. From these diagrams it is possible to obtain by interpolation the indicated power for any period of admission.

The economical performance of the engine was unusually good, the steam consumption with saturated steam being only 11.82 pounds per indicated horse-power per hour under load with the most favorable period of admission, and with no load only 13.7 pounds. For a tandem compound engine of 250-horse-power, this is a very unusual performance; the same is true with respect to the consumption of steam and heat with superheating, which gives a rate of consumption at 256° superheating of 9.62 pounds of steam and 1215 British thermal units, dropping to 8.99 pounds of steam and 1170 British thermal units, with a superheating of 343° Fahr.

The small steam consumption at no load is notable. In ordinary tests, the measurement of feed water at no load is usually omitted for the reason that the effects of all sources of error render an excessively long test necessary; in this case, however, the measurement was simple and accurate at all loads. With superheated steam, it was not possible actually to measure the consumption at no load, so that the values given in the tables for these tests were extrapolated from measured values of the steam consumption.

On account of the unusually economical results obtained with saturated steam, the relative gain in economy by superheating was not so marked as has been observed in

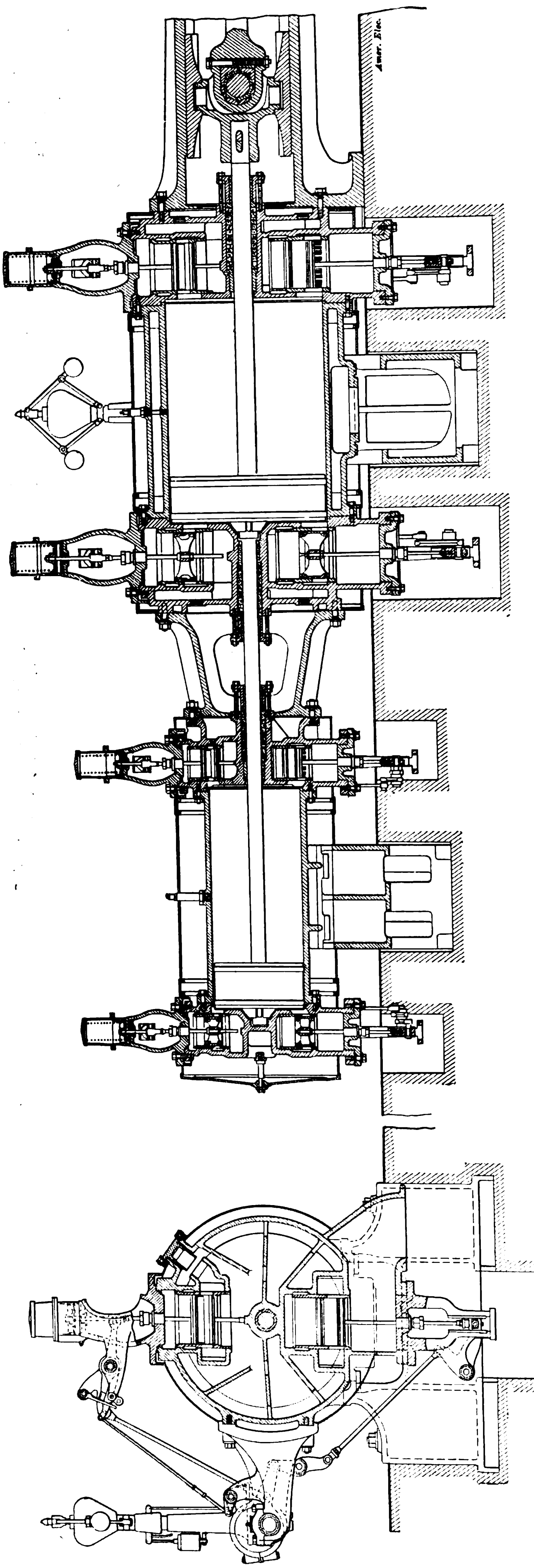

FIG. 4.—TRANSVERSE AND SIDE SECTIONAL ELEVATIONS OF A VAN DEN KERCHOVE ENGINE USING SUPERHEATED STEAM.

other cases; for such a case as this, the saving in coal would alone indicate the gain, and that determination was not made for reasons already mentioned. On the other hand, the result of the second group of tests is of the greatest importance because the superheating was variable, while the power was kept constant. The results show that the consumption of steam progressively superheated falls off regularly. Test No. XV., which lasted 5½ hours, was made to compare the usual method of obtaining steam consumption by measuring the feed water of the boiler with that of measuring the condensed steam. It is well known from experience that the first method usually gives slightly larger results than the second, because leakages might cause the loss of steam, and errors are involved in the determination of the water level of the boiler. In the actual case, taking ordinary precautions, there was a difference of 6.6 per cent between the consumption as determined from the condensed steam and from the feed water, and no leaks were discoverable. On account of this discrepancy the matter was carefully looked into and new comparative measurements made. After the pipe which connected the lower part of the glass water column to the boiler, which was found to be badly arranged, had been modified, the discrepancy fell directly to 3 per cent, and after investigating all possible causes of leakage, a final test was made in which there was only a difference of 1.25 per cent, which is probably as small as it can be made.

Figs. 1 and 4 show a 2000-h.p. Van den Kerchove engine, which is similar in construction to the one on which the test was made, differing from it only in size. It will be noticed that the steam jackets are so arranged that they completely enclose the admission passages. The valves are placed in the cylinder heads, as shown, the admission being above the exhaust. Each valve operates by its lower edge only, and is kept tight by metal packing rings at the top and bottom edges. The valve has a free way through its center, and is thus balanced. As there is no seat for the valve to fall upon when released by the trip, the lower side of each dashpot piston is faced with leather, and this falls upon the bottom of the dashpot. The steam enters around the admission casing and under its lower edge, passing thence to the cylinder through slots in an inset cylindrical seat and through a ring channel surrounding this seat and opening in the inside surface of the cover. It will be noticed that these piston valves differ from the usual American type of piston valve in that they close by a trip disengagement, and under spring and dashpot control, and they each act at one edge or end only.

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Cement for Marble.—The *Bandische Landes Zeitung* says that an excellent cement for broken marble consists of four parts of gypsum and one part of finely-powdered gum arabic. Mix intimately, then with a cold solution of borax make into a mortar-like mass. Smear on each face of the parts to be joined, and fasten the bits of marble together. In the course of a few days the cement becomes very hard and holds very tightly.

PIPE COVERINGS.

BY R. T. STROHM.

The materials used for pipe coverings are many and various, and the coverings consist sometimes of single substances and sometimes of mixtures of several. Asbestos, hair-felt, magnesia, cork, mineral wool, pressed paper, saw-dust, charcoal, ashes, slaked lime, coke and pine wood have all been used with varying degrees of success, although many of these are not common, and are used only in special instances. A good pipe covering must possess several distinctive merits, which will be mentioned in the order of their importance. First, the material must prevent the passage of heat between the pipe and the surrounding atmosphere, outwardly in the case of a steam pipe, and inwardly in case the pipe conveys brine for refrigerating purposes.

A bare steam pipe dissipates heat from the steam in three ways: by radiation, by conduction, and by convection.

The covering must then be able to reduce or prevent to a great extent all these losses. To obstruct the passage of radiant heat is not a difficult matter, since there are numerous substances which will accomplish this purpose. But the covering must also prevent loss by convection and conduction. The heat of the steam is imparted by contact to the inner surface of the pipe, and iron being an excellent conductor, the heat is rapidly transmitted to the outer surface. Here, if the pipe is bare, the air immediately surrounding the pipe is heated by contact, and this air rising because of its lower specific gravity, gives place to unheated particles. This induces a circulation, the heated particles rising and conveying their heat to the more distant ones, constituting the process of convection. Consequently, in order to reduce the loss due to convection, there must be no circulation of air or other medium between the pipe and the covering. In other words, the covering must either fit snugly to the pipe, or it must entrap the air in small cells or chambers which will not permit of circulation. In order to prevent loss by conduction, the covering must obviously be made of material having a low thermal conductivity. All of the substances mentioned in the first paragraph possess the foregoing requirements to a greater or less degree, and are therefore available as coverings. But hair-felt, asbestos, cork and magnesia have a much higher efficiency than the others in this respect.

The second requisite of a good covering is durability. That is, it must bear the wear and tear of service and the heat of the steam without losing its non-conducting qualities, and without necessitating frequent renewals. There are very few of the most efficient non-conductors which can be used alone as coverings, owing to the fact that in such a state they would be unable to withstand abrasion and ordinary atmospheric changes. The usual method is to make them into shapes or molds held together and rendered durable by means of wire screens, or canvas jackets to which the material is attached. As a consequence, fibrous substances are used to a large extent in the manufacture of pipe coverings, for the purpose of providing a binding material, just as hair serves as the binding material in mortar. Thus, asbestos fiber and hair are used in considerable proportions in many pipe coverings. These materials possess not only the requisite binding qualities, but both are likewise excellent non-conductors.

This question of strength and elasticity or toughness is one which must be taken into consideration in many cases in selecting a pipe covering. It frequently happens, where pipes are carried along the top of a battery of boilers, that they form convenient foot-bridges for the engineer or fireman in inspecting the condition of the pipes and fittings. This is hard on the covering, and if it is of a fine granular or plastery composition, it will likely be ground to dust by the pressure, and will let the covering sag beneath, admitting an air circulation and leaving the pipe partially unprotected at the top. Or it may be that because of the presence of steam hammers, or because of the vibrations set up by steam engines or other machinery, the pipe line will be subjected to incessant jarring. If this be the case, the covering must not crumble away under the effects of the repeated shocks. This means that the covering should be of a fibrous nature, so as to secure the necessary elasticity and strength.

Third, the covering must be comparatively light in weight. Large pipe lines are heavy in themselves, and where they are of great length, the stresses set up are at times severe. Therefore it is desirable to have a covering which shall possess as little weight as possible, consistent with good non-conducting qualities. The principal materials now used, such as cork, hair-felt, magnesia and asbestos, are not heavy, and do not add appreciably to the stresses in the pipe.

With any given material, the ability to prevent loss of heat varies directly with the thickness. That is, the thicker the covering, the less the loss. It would seem, therefore, that a thickness could be reached with which no loss of heat would occur. This is theoretically true. But the saving due to decreased condensation would be far outweighed by the increased expense due to the extra material in the covering. Practically, a thickness of from 1 in. to 1¼ ins. is the economical limit, since the additional heat saved by adding thicker covering is so slight as to scarcely justify the outlay for more insulating material.

Fourth, the covering should be fire-proof. The tests to which pipe coverings are put are often severe. If the pipe line carries high-pressure or superheated steam, the temperature will be high, and the covering must of course be able to withstand this heat. The earthy materials such as magnesia, asbestos, mineral wool, lime and ashes will not be affected by the heat, no matter how great it may be. Organic substances, on the other hand, may be rendered quite valueless by subjection to high temperatures. While it is desirable that a covering should be fire-proof at all temperatures, it is absolutely essential that it shall be so at the temperature to which it is to be subjected when put into actual service. This is quite as much for the sake of safety as for the durability of the covering. Hair-felt, on this account, ought not to be used in direct contact with the steam pipe, since it is combustible, and deteriorates rapidly when subjected to great temperatures.

Fifth, there must be nothing in the composition of the covering which can in any way injure the pipe to which it is applied.

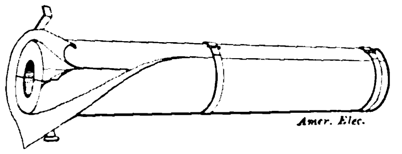

FIG. 1.—SECTIONAL PIPE COVERING.

Many coverings are made by the mixture of several different materials. Where this is done, there must be no corrosive ingredients which could attack the iron in any form. The sulphur which is found in some of the cheapest coverings is injurious.

Pipe coverings may be divided into two general classes, according to their forms, namely, plastic and sectional. Plastic coverings are made up into a paste or mortar, and are so applied to the surfaces which they are intended to protect, being allowed to dry and harden there. The plastic coverings possess the advantage of being applicable to any shape of pipe whatever, as well as to boilers, separators, heaters, reheaters, receivers and the like. They entail the disadvantages, however, that they cannot be removed without being destroyed altogether, and that it is impossible to examine the seams or joints which they cover without tearing them down.

Sectional pipe coverings are by far the more common. These are made by molding the mortar of non-conducting material into lengths of about three feet, cored to fit snugly to the size of pipe for which it is intended. This length is molded in similar halves, which are then pasted to a strip of canvas, as shown in Fig. 1. This canvas is made somewhat longer than the section, and also wider than the outer circumference of the covering. In putting it in place on the pipe, the section is laid open and placed around the pipe. Then the canvas flap is coated with paste and pasted down tightly, to secure the section to the pipe. In order to give a continuous line of covering, the short projecting lap of canvas at the end of the section is made to fit over the end of the next adjoining section. This prevents any loss by air circulation through the spaces between adjacent sections. The piece is then further secured to the pipe by

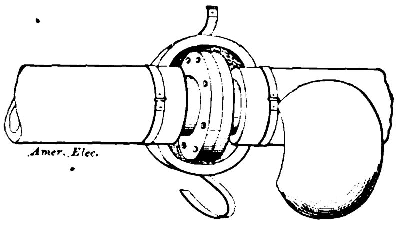

FIG. 2.—REMOVABLE COVERING FOR PIPE FLANGE.

metal bands, one at the middle and one at each end. These bands are usually of brass, and the outer casing of canvas is generally white. Sectional coverings are usually built for straight pipes of uniform diameter, and must be made to special order in case they are to be applied to irregular surfaces or shapes. They are easily and quickly placed in position, and just as readily removed, without any apparent damage to themselves. Recently, sectional coverings for the protection of pipe flanges have been made, and Fig. 2 shows such a form, having one-half of the section removed from the pipe to show the flange.

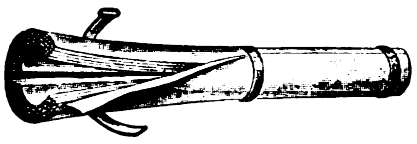

FIG. 3.—CORRUGATED AIR CELL COVERING.

The best non-conducting covering is that one which contains the greatest number of individual air cells or dead air spaces in its composition, for stagnant air, or air without the least circulation, is the most efficient non-conductor known. And further than this, it has been found that organic substances, when in first-class condition, are far better insulators than inorganic substances. But on the other hand, the mineral substances are far better than an organic material which has deteriorated. For example, hair-felt possesses an extremely high efficiency as a non-conductor, for the reason that it holds a large number of dead air spaces well distributed. However, it is expensive, and unsafe for high temperatures. Wherever it is used, a sheet of asbestos paper ⅛ in. thick should be placed between it and the pipe.

Realizing that air spaces add to the value of the covering as a non-conductor and at the same time reduce its weight, makers have produced various types of coverings containing these air-cells. Two of these types are shown in Figs. 3 and 4. Both are made of alternate layers of flat and corrugated asbestos board. In the former, the corrugations run in a longitudinal direction, while in the latter they run circumferentially around the pipe. It is better to have the air spaces run around the pipe than lengthwise of it, especially if the pipe be a vertical one, since it gives a larger number of individual air spaces and effectually prevents circulation.

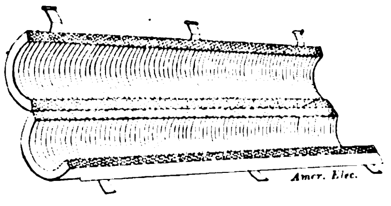

FIG. 4.—CORRUGATED AIR CELL COVERING.

Cork has proven to be a most desirable covering, being not only an efficient non-conductor but also quite durable. It is, of course, an organic substance, but it is fireproof at the temperatures of the steam pipes to which it may be applied, and it shows no tendency to disintegrate under the effects of the heat from the pipe. This covering is made by compressing granulated cork in iron moulds of the proper size and form, and at the same time subjecting it to a temperature of 500° Fahr. No foreign substances are used for binding material, the natural gums of the cork becoming plastic under the effects of the heat and serving to cement the particles of cork firmly together, and at the same time giving extreme porosity to the covering. Thus made, cork covering possesses the necessary elements of lightness, strength, durability and freedom from any substance which could corrode the metal of the pipe. It has a layer of asbestos paper inside, next the pipe, and an outer covering of canvas, as in the other forms of sectional coverings.

Mineral wool forms an excellent pipe covering, and is used to a considerable extent. It is, as its name implies, a mineral substance, being composed of silica. The siliceous matter is melted in a cupola at a temperature of 3,000 degrees or more, after which it is allowed to flow out in a continuous stream. A jet of mixed steam and air is injected into the molten stream, breaking it up into a large number of fine portions. The resulting mass is of a porous nature, and contains numerous air-cells, which give it its value as a non-conductor. It is brittle, and can be readily pulverized, and therefore is not suitable for covering steam pipes subject to vibrations. Furthermore, it is likely to contain sulphur, which is apt to corrode the pipe if moisture be present. However, improved methods of manufacture have been devised which produce mineral wool free from sulphur. This product is also known as slag wool, silicate cotton and mineral cotton.

In applying plastic coverings, the insulating material is first made into a thick mortar. The hot surface is then thinly coated with this paste, and it is allowed to dry. After this, a second thin layer is applied and allowed to dry, the building-up process being thus continued until the desired thickness has been reached. The reason for allowing the successive layers to harden thoroughly in turn is to prevent shrinking and cracking. If a single layer of the requisite thickness were applied, it would shrink in drying to such an extent as to seriously impair its value as a covering, either by reason of the cracks in it, or because of the falling off of portions, leaving the pipe exposed. The surfaces to which the cement or mortar is to be applied must have no rust, dirt or grease on them, otherwise the covering will not adhere firmly, and will easily jar loose. In many cases, as in covering large heaters or boiler surfaces, a net-work of iron wires or a lattice-work of iron strips is placed over the surface, giving a foundation upon which the cement will hold easily. This further aids in reducing the heat loss by interposing air-cells. A smooth finish is given to the plastic coverings by rubbing with the trowel after the last layer has been partially dried.

In many cases it is desirable to prevent the passage of heat to a pipe, as in the case of pipes in refrigerating and ice-making plants. The non-conducting quality of the covering is essential under these conditions also. But there is another element which enters into the discussion where brine pipes are considered. This is the moisture which is necessarily precipitated when a pipe of low temperature is led through atmospheric air containing water particles. This process of sweating soon collects enough moisture to saturate the covering thoroughly, and as a consequence the covering must be so constructed as to successfully withstand the effects of moisture. This object may be attained by treating the covering material with some substance which will render it non-absorbent. Cork, being altogether impervious to water, needs no treatment.

It will be noticed that in almost every instance the outer surfaces of pipe coverings are either white or of some light tint. There is an excellent reason for this. A surface of light color will radiate less heat than a dark one. A white or bright polished surface will reflect heat rays, while a dark surface will transmit or absorb them. By using an outer casing of white canvas, or by painting the surface with a light paint, the radiation loss is lessened, while the paint adds further protection against the effects of atmospheric changes.

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Grease in Boilers.—The action of grease in a boiler is peculiar, but no more so than might be expected. It does not dissolve in the water, nor does it entirely decompose. Neither does it remain on top of the water; but it seems to form itself into what may be described as "slugs," which at first seem to be slightly lighter than the water; of just such a density in fact, that the circulation of the water carries them about at will. After a short season of boiling, these "slugs" or suspended drops, seem to acquire a certain degree of stickiness, so that when they come in contact with the shell and flues of the boiler they begin to adhere thereto. Then under the action of heat they begin the process of "varnishing" the interior of the boiler. The thinnest possible coating of this varnish is sufficient to bring about overheating of the plates. We emphasize the point that it is not necessary to have a coating of grease of any appreciable thickness to cause overheating and bagging of plates, and leakage at seams. The time when damage is most likely to occur is after the fires are banked; for then the formation of steam being checked, the circulation of water stops, and the grease has a chance to settle on the bottom of the boiler and prevent the contact of water with the fire sheets. Under these circumstances, a very low degree of heat in the furnace is sufficient to overheat the plates to such an extent that bulging is very likely to occur. Of course there is greater likelihood of trouble with some kinds of oil than with others, animal oils being most troublesome, and mineral oils least so. When oil is used to remove scale from steam boilers too much care cannot be exercised to make sure that it is free from grease or animal oil. Nothing but pure mineral oil should be used.—*Exchange.*

Abstracts from Foreign Contemporaries

An Electrical Ore Finding System.—The London *Electrician* describes an electrical system for finding ores devised by Leo Daft and Alfred Williams, a test of which was given at the Telacre Mines, Prestatyn, North Wales. The method employed is an extremely simple one, and requires no expert knowledge of either electricity or mining in order to operate it. As may be seen by a diagram of connections, the transmitting apparatus consists of a large induction coil, the secondary of which is earthed and shunted by a condenser. The parallel and series spark-gaps shown were not used in the experiments referred to herein, owing to the peculiar nature of the sub-soil, nor was the transformer in the receiving circuit used, but with these exceptions the apparatus employed was exactly as shown. Secondary batteries were employed to energize the induction coil, and the potential at the terminals of the secondary winding was about 30,000 to 40,000 volts. Earthing was effected by means of steel spikes driven about 9 ins. into the ground, and these spikes were connected to the coil by rubber insulated wire. As a matter of fact, each secondary coil was earthed in three different spots, and by means of a switch it was possible to work with any pair. One pair was taken down the shaft of the mine and earthed with the spikes about 100 yards apart, practically on the same level; another pair was earthed under similar conditions on the surface, and one spike of the third pair was above ground, while the other was some 30 yards immediately beneath it, in an old working. The receiver terminals were similar to those of the transmitter, but were earthed at about only 30 feet apart, and at a distance of, roughly, a ¼ mile from the transmitter. The belief held by the inventors is that electric impulses or waves are radiated out of the transmitter in ever-widening circles, and that, therefore, the line of maximum intensity, or a line on which they should obtain the loudest effects in a telephone receiver, will be found at right angles to a straight line joining the two transmitter terminals, and drawn through its center. That is to say, when the receiver spikes are stuck in the ground in the immediate neighborhood of this line, and the receiver responses are found to be louder than at any other spot on a semi-circle drawn through this point with its center midway between the two transmitter terminals, then it may be assumed that the conditions are normal and that no metallic lode exists in the immediate neighborhood. But if the best effects are not heard in the receiver when it is over or near this line of maximum intensity, but at a point some distance away, then it may safely be inferred, according to the inventors, that a metalliferous vein does exist within no great distance. By varying the position of the transmitter spikes it is possible to throw the line of maximum intensity in any desired direction, which may be selected at random or from geological knowledge of the locality. In the experiments under consideration the transmitter was earthed, in the case of the surface terminals, near the head of the shaft and the line of maximum intensity thrown across a field, which was divided from others by iron-wire fencing. On exploring with the receiver it was distinctly found that normal conditions did not exist, practically no sound being audible in the sensitive telephone receivers, but on moving across the field a sound was heard which gradually increased to a maximum when an angle of about 30° to 45° with the line of maximum intensity had been reached. Similar tests, when using the points which were earthed underground, gave similar results, and it was, therefore, conjectured that a vein of lead ore lay under the spot where the loudest sounds were heard. It is assumed that the impulses or waves are diverted from their normal course by a metallic lode, and hence the distortion of the electrical field and consequent effects on the telephone receivers. Curious phenomena occasionally occur in the form of condenser effects which give rise to the familiar crackling sound in the receiver, commonly heard when working with high potentials in conjunction with condensers. It is also possible to obtain a nodal point immediately over a vein of metal which would cause silence, and might lead to the supposition that the conditions were quite normal; but this is a very unusual occurrence, and the cause would soon be discovered by moving the receiver spikes about slightly, when loud sounds would be heard. These sounds are in all cases, except that due to the condenser effect just mentioned, a reproduction of the make-and-break of the transmitting induction coil. The inventors assert that they have, in one instance, discovered a new vein of metal in an apparently worked-out mine, and that on recommending work very successful results were obtained. It is somewhat difficult to see how the system could be used to determine with any degree of accuracy, the depth, nature or quality of the lode, and therefore to be able to say whether or not it would be worth attempting to recover, but if it would only locate the position of the ore an enormous advantage would be gained.

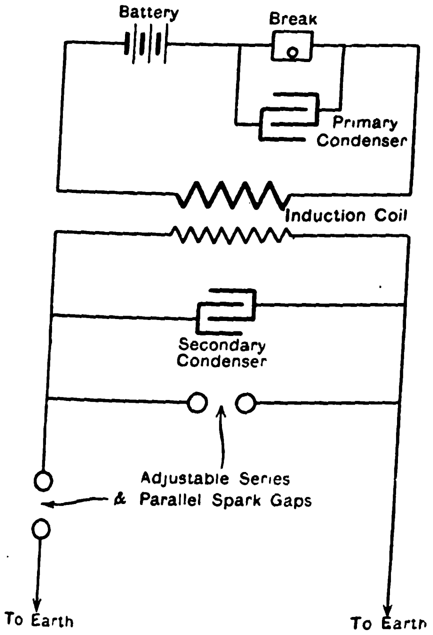

FIG. 1.—TRANSMITTER CONNECTIONS.

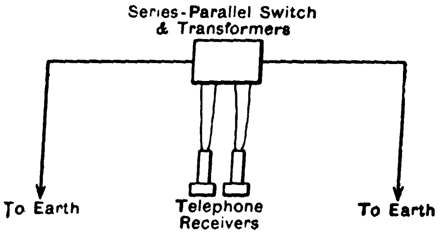

FIG. 2.—RECEIVER CONNECTIONS.

Parallel Operation of Alternators.—L. Drin contributes to a recent issue of *Revue Pratique de L'Electricité* an article on the operation of alternators in parallel, and considers the different methods of securing satisfactory results. Analytically, the problem indicates that the load should be divided uniformly among the various units for suitable operation, and this is obtained by equalizing the potentials of all the machines. To maintain a constant pressure on the circuit it is necessary to regulate the machines by connecting together the regulating rheostats; or if the armature reaction is not excessive, by adjusting them one at a time. Three methods are considered for the distribution of load,—the methods of plural, unit, and central regulation. The first consists in fitting each prime mover with an independent governor, so that variations in the load on the system will be taken care of by all the generators, and in order that the operation shall be successful it is necessary that all the regulators should have the same sensitiveness, since the unsatisfactory operation of any unit might introduce serious trouble and cause surging, which is difficult to stop. A system which increases or decreases the load on all the machines simultaneously is evidently poor from the view-point of economy, and to avoid this some engineers have proposed the unit system of regulating. This consists of regulating the speed of the system by a single governor, acted upon by one engine. In this case the regulating machine must be large enough to take care of all variation in load on the system, and if these variations are great, the method may not be satisfactory. M. Rateau suggests a modification of this. He proposes adjusting the governors of all the engines for slightly different speeds. Then, during operation, variations in the load would be taken up by one machine until its full capacity is reached, when it will then fall back upon the next machine, and so on. The author suggests a slightly different arrangement, which is to run all of the generators at something under full load, with one machine for taking up variations. When the latter reaches its full capacity it will then fall back upon the remaining generators. The system has been tried and gave satisfactory results. The central system of regulating consists in having one governor, placed in the steam main, control all the engines. So far no satisfactory mechanical governor has been found for this purpose, and it is suggested that possibly an electrical governor operating upon the wattmeter principle might give satisfactory results.

Simple Expansion Steam Trap.—*The Mechanical Engineer*, of London, describes a simple and effective form of steam trap, a sectional view of which is shown by Fig. 3 herewith. It consists of a body, A, having an inlet aperture and chamber, A_1, and an outlet aperture and chamber, A_2, and a web, A_3, dividing the one from the other. To the body, A, is fixed a tube, B, of considerable length, and to the web, A_3, is rigidly fixed another tube, C, which rises up within the outer tube, B, nearly to the top thereof and communicates with the inlet aperture and chamber, A_1, by a central hole, A_4, in the web, A_3. The outlet aperture and chamber, A_2, communicates with the space between the two tubes, B C. The upper end of the tube or case, B, has a cap, B_1, screwed thereon, and through this cap, B_1, is screwed a pin, D, to which is connected, by pin joint, D_1, a valve, E, which seats itself on the upper end of the internal tube, C, the valve being guided by a winged stem, E_1, fitting the interior of tube, C. The valve is capable of regulation from the exterior by means of a hand wheel, D_2, fixed on the screw-threaded pin, D, and it can be locked in its regulated position by a lock nut, F. By these means the steam entering the trap will first heat it, and, by expanding the tube, C, will cause the latter to press against the valve, E, and so close the passage to the outlet, A_2. When a certain quantity of condensation water has collected it cools and consequently contracts the tube, C, and thereby withdraws it from the valve, E. The condensation water is thus allowed to be discharged until the tube, C, is again heated and expanded by the incoming steam.

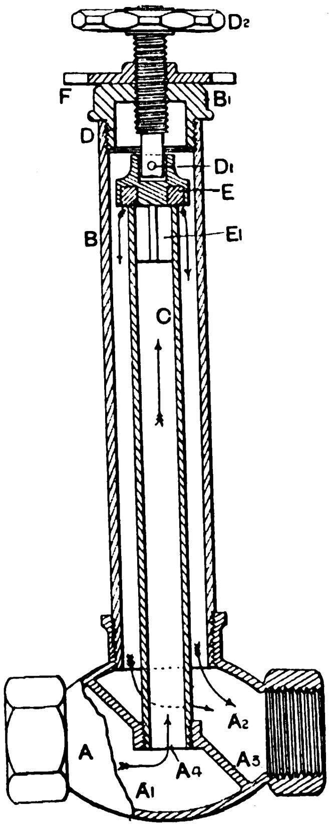

FIG. 3.—EXPANSION STEAM TRAP.

New Circuit Controller.—A new device for controlling circuits has been invented by S. Z. de Ferranti, in which a property of an electrolytic cell is used as a protection against excessive rise of voltage. Certain metals, such as aluminum and chromium, when used as anodes, form a coating which greatly increases the internal resistance of the cell, so that it will stand a potential approaching 100 volts without breaking down, although passing a small current. If a certain critical voltage be exceeded, the resistance of the cell breaks down, allowing a much larger current to pass through. If the potential be then lowered the current is again choked back, owing to the coating which has been formed reasserting its high resistance. The invention is applicable to both direct and alternating currents, although in the latter case both electrodes must be of the particular metal used. The electrolyte may be a solution of bichromate of potash, sodium phosphate, or a soap solution. The accompanying illustrations, taken from the London *Electrician*, show various applications of the device. Fig. 4 shows a solenoid arranged to prevent a switch being opened until the current has fallen to a sufficiently low value; Fig. 5 shows an arrangement whereby the cells can be introduced into the shunt circuit one after the other, and Fig. 6 shows a form of multiple oil break switch used in conjunction with a number of electrolytic cells. In the illustrations, the generator is represented by *e* and the load by *f*. Referring to Fig. 4, when the current has fallen off to a sufficiently low value, the plunger or armature, *i*, will be released, and in this particular arrangement fall of its own weight, and move the catch, *k*, from the path of the switch arm, thus permitting the switch to be further operated to break the circuit, or to automatically produce this movement itself, either by the force of gravity or by a spring, *l*. The number of cells employed in series must be adjusted to the potential of the circuit, so that the total voltage is not sufficient to break down all the cells. In the arrangement, shown diagrammatically by Fig. 5, at first there is only, say, a single cell or batch of cells included in the circuit, whose voltage is many times greater than the critical voltage of each cell or batch which, therefore, passes a large current. On moving the switch another step a second cell or batch of cells is included, thus to a small extent diminishing the current, and so on until such a number of cells has been introduced that the sum of their critical voltages is above that of the circuit into which they are inserted. Their resistance then builds up and chokes back the current to the required small value. The circuit may then be opened entirely by the switch as before, either automatically or by hand, or the small current may be left flowing. In closing a circuit by means of a switch combined with such cells the reverse action takes place. On first making the circuit the potential sends a small current through, but cannot break down the resistance of the cells, which are then cut out one by one, and, when a sufficient number have been cut out by the switch, their resistance breaks down and the current rises to nearly its full value, which it reaches when all the cells have been cut out, when they may be short-circuited. The switch employed may be of any ordinary character, operating by means of sliding contacts or in any other suitable manner.

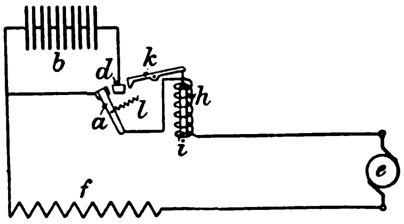

FIG. 4.—NEW CIRCUIT CONTROLLER.

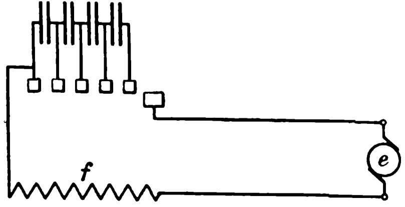

FIG. 5.—FERRANTI CIRCUIT CONTROLLER.

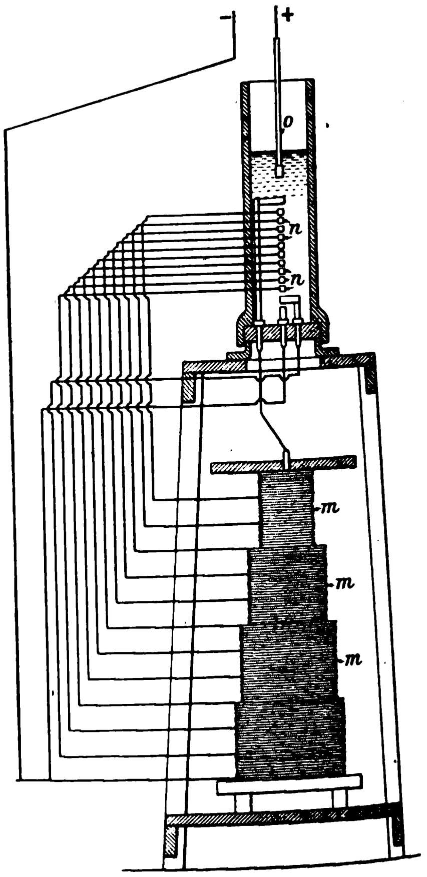

FIG. 6.—MULTIPLE OIL BREAK SWITCH.

In another arrangement cells having this property are employed in conjunction with a fuse break in a similar manner to that employed for the switch break just described, and the effect of sudden rupture of the circuit will be thereby avoided. The fuse may be of any ordinary character, and may be immersed in oil if it be required for high-tension work. Instead of the switch just described, a single or multiple oil break switch may be used. Such a combination is very effective for charging and discharging cables used for carrying alternating currents at high potentials. In this arrangement (see Fig. 6) the separate cells are conveniently arranged in the form of dishes, *mm*, piled one above the other, distance pieces of insulating material being used to separate the different dishes. This arrangements obviates the necessity of having each pair of electrodes in a separate containing vessel, as the dishes act both as electrodes and containing vessels. It is also advantageous to have the dishes of graduated size, decreasing to the top, as shown in the drawing, the cells of smaller size being coupled to the contact points of the switch, so that they come into the circuit last in breaking and are the first to be cut out in closing the circuit. As shown, the contact points, *nn*, are so connected to the dishes that, as the movable contact-piece, *o*, moves downwards, one batch of cells after another is cut out until the resistance breaks down, and the remainder may be short-circuited.

The device may also be used as a lightning arrester, a sufficient number of couples being connected in series to prevent the normal voltage of the circuit from passing a large current through them. When the lines are struck, the cells will permit current to flow until the discharge has taken place, when the initial resistance of the cell will be re-established, stopping the current.

Governors for Internal-Combustion Engines.—Figs. 7 and 8 show an arrangement of governor for internal-combustion engines invented by W. J. Crossley and W. Webb, and described in the London *Mechanical Engineer*. *A* represents the cylinder of the engine, *B* the exhaust valve, and *C* the cam shaft used for operating the valve gear and governing gear. The exhaust valve lever is shown at *D*, and the cam for operating it at *E*. The governor, *F*, is driven by bevel gear wheels contained in the casing, *G*. The governor lever, *H*, has one end pivoted at *J*, the other end being raised or lowered by the action of the governor. If the speed of the engine rises, the governor balls fly outward and the end of the lever, *H*, is raised. From this lever hangs the rod *K* with the knife-edged governor die, *L*, fixed on it. The knife-edged governor blade, *M*, is fixed on the lever *N*. A reciprocating motion is imparted to the lever, *N*, and blade, *M*, by the cam *O*. The governor die, *L*, is free to slide up and down the block, *P*. This block, *P*, is pivoted to one end of the bell crank lever, *Q*. The other end of this lever carries a swivelling piece, *R*, working in a groove in the roller, *S*. The method of operating this gear is as follows: When the engine is running at, or somewhat under, its normal speed the governor lever, *H*, hanging rod, *K*, and die, *L*, are in the position shown by Fig. 8. As the cam shaft revolves the cam, *O*, moves the lever, *N*, pushing the blade, *M*, forward, the knife-edge of which engages with the die, *L*, thus moving it and the bell crank lever, *Q*, forward. This pushes the roller, *S*, along the pin, *T*, of the exhaust valve lever, *D*, into such a position that it "fills a gap," and the exhaust cam, *E*, in revolving meets with the roller, *S*, depresses the lever, *D*, and lifts the exhaust valve, *B*, allowing any pressure in the cylinder, *A*, to escape by way of the port, *U*. The cam, *E*, then allows the spring, *V*, to close the exhaust valve, and the cam, *O*, allows the spring, *W*, to bring the bell crank lever, *Q*, roller, *S*, and die, *L*, back to the position shown. When the speed of the engine rises above the normal, the governor raises the die, *L*, clear of the blade, *M*, so that when the latter is pushed forward by the cam, *O*, it cannot engage with the die, with the result that the bell crank lever, *Q*, and roller, *S*, remain stationary, as shown, so that the exhaust cam, *E*, in revolving, does not meet with the roller, *S*, and the exhaust valve therefore is not opened.

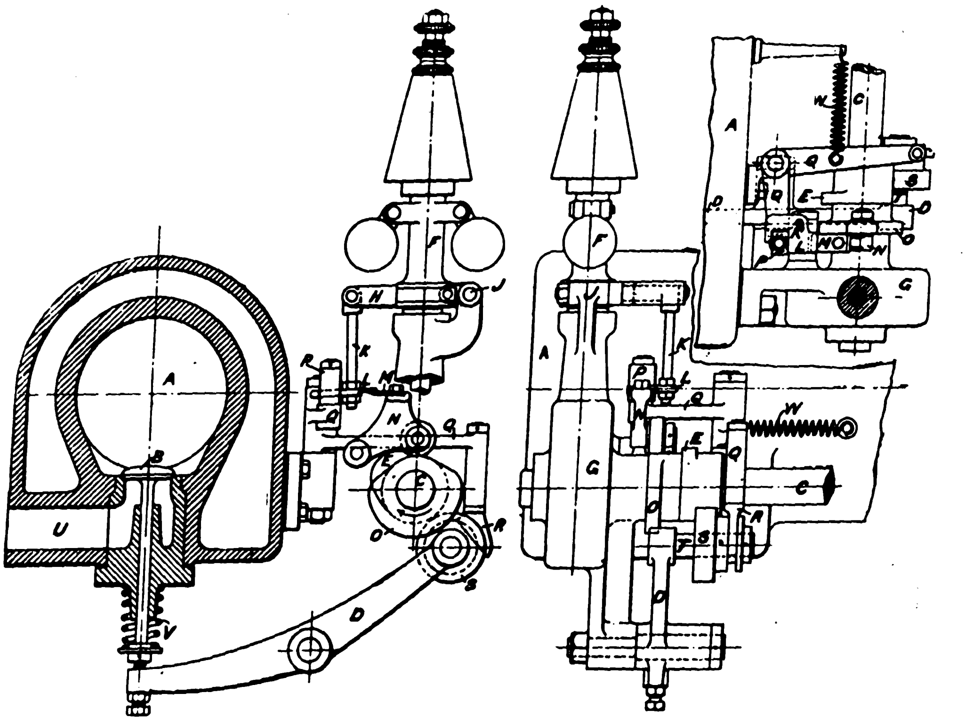

FIG. 7.—GOVERNOR APPLIED TO A HORIZONTAL GAS ENGINE. —FIG. 8.

Another arrangement, applied to a vertical engine, is shown in Figs. 9 and 10, and operates as follows: When the speed is at,

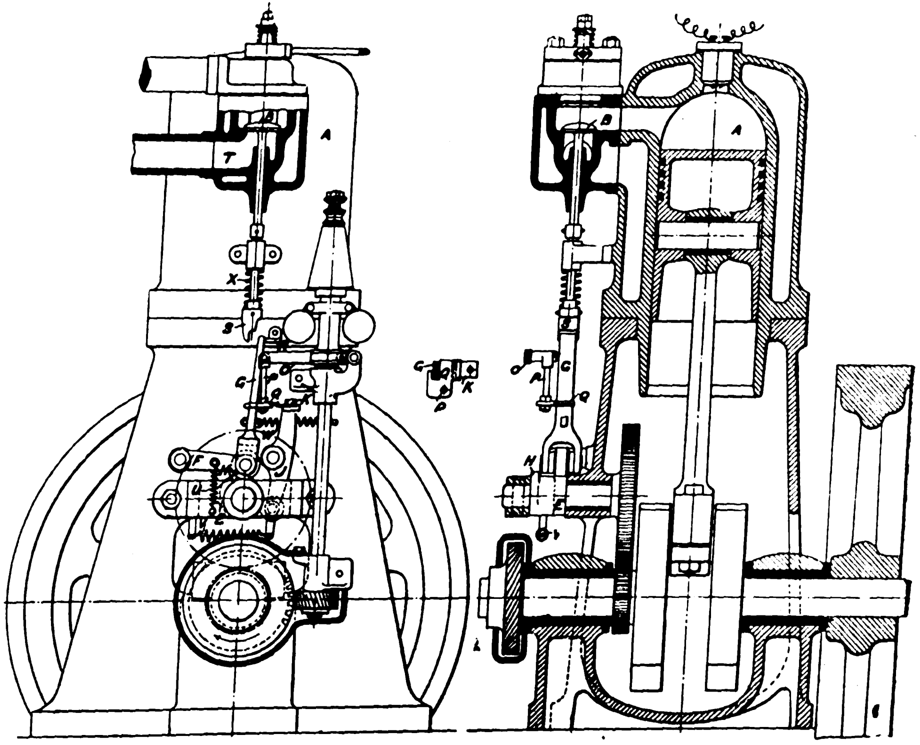

FIG. 9.—GOVERNOR APPLIED TO A VERTICAL GAS ENGINE.—FIG. 10.

or somewhat under, the normal number of revolutions per minute the governor lever, *O*, the hanging rod, *P*, and the knife-edged die, *Q*, are in the position shown in Fig. 9. As the cam shaft revolves the cam, *H*, pushes forward the lever, *J*, and the blade, *K*, "hits" the die, *Q*, moving the end of the pusher, *G*, under the block, *S*, which is attached to the spindle of the exhaust valve, *B*, thus "filling a gap" in the exhaust valve gear. The exhaust cam then lifts the lever, *F*, the pusher, *G*, and the block, *S*, thus opening the exhaust valve and allowing any pressure to escape from the cylinder, *A*, by way of the exhaust port, *T*. The cam, *E*, then allows the spring, *U*, to bring the exhaust valve lever back, thus allowing the spring, *X*, to close the exhaust valve. The springs, *V* and *W*, bring back respectively the lever, *J*, and the pusher, *G*, to the position shown. When the speed of the engine rises above the normal the governor raises the die, *Q*, clear of the blade, *K*, so that when the latter moves forward it "misses" the die, and the pusher therefore remains in the position shown, the gap not being filled. Then when the cam, *E*, revolves the lever, *F*, is lifted together with the pusher, *G*, but the upper end of the latter, not being in line with the block, *S*, the pusher, in rising, does not lift the block, *S*, the exhaust valve therefore remaining closed.

SOME RECENT ELECTRICAL PATENTS

Synchronism Indicator. — It is well known that in the early days of the practice of operating alternators in parallel the machines were brought as nearly as possible into synchronism by means either of lamps connected to suitable transformers or voltmeters similarly connected. Alternating-current practice, however, is rapidly outgrowing relatively crude methods such as this, so that it is becoming common nowadays to find instruments in use which indicate positively synchronism or the lack of it. One of the simplest of these is illustrated diagrammatically by Fig. 1 herewith, which is taken from a patent issued to Mr. J. E. Woodbridge, of the General Electric Company. The indicator consists merely of two coils disposed co-axially, one stationary and the other movable, as in an ordinary electrodynamometer, and the movable coil being held normally at right angles with the stationary one by a spiral spring. One coil is connected to one phase of a machine already in operation, and the other coil is connected to the *other* phase of the machine which it is desired to put into circuit. Consequently, in order to indicate synchronism, the current in one coil must be in quadrature with the current in the other coil, and when this is the case the currents obviously do not react upon each other and the needle remains at zero. It is necessary to use in connection with this indicator, however, synchronizing lamps connected as shown at 7, 7, so as to indicate whether the e.m.fs in corresponding phases agree with each other or are 180° apart, the indicator itself not taking care of this part of the problem. The lamps as shown in the diagram are connected for "synchronizing dark," but of course may be connected either this way or to indicate similarity of e.m.f. sign when they are bright. Simultaneous observation of the lamps and the indicator will serve to show not only synchronism, but which of the two machines is running faster than the other. Assuming that the instrument is connected so that when machine *A* is behind machine *B* less than one-half a period the pointer is deflected to the right, then it will obviously be deflected to the left if machine *A* is ahead of machine *B* less than one-half a period. Under these conditions, if the synchronizing lamps grow dim while the needle is deflected to the right and brighter when it is deflected to the lefit, then machine *B* will be running more slowly than machine *A*, and *vice-versa*. Patent No. 722,345.

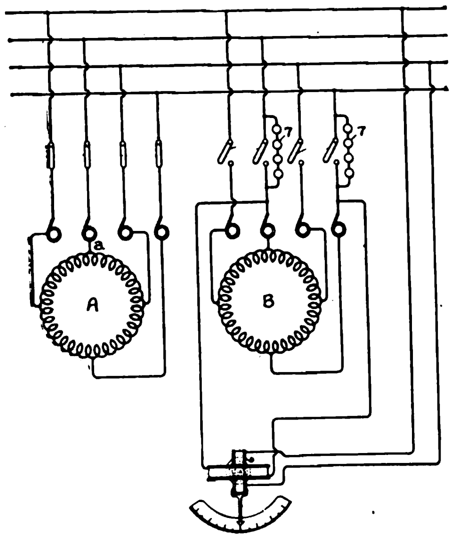

FIG. 1.—SYNCHRONISM INDICATOR.

Induction Coil. —Fig. 2 herewith illustrates a peculiar form of induction coil and an ingenious method of operation devised and patented by Albert L. Parcelle for the purpose of increasing the secondary e.m.f. or current induced in an induction coil by means of slight variations in the resistance of the primary circuit. The coil itself has two cores, as the engraving clearly shows, each being provided with an individual primary winding. The engraving shows the two primary windings excited by separate batteries and with the circuits distinct from each other, but it is obvious that a single battery may be used for both circuits provided the connections be made properly. As shown in the diagram, the variation in the resistances of the primary circuits is effected by means of a double telephone transmitter, consisting of two stationary electrodes, a^5 and b^5; two movable electrodes, a^6 and b^6, connected rigidly to each other and to a diaphragm, *e*, by means of the pin, *d*, and high resistance material, a^7 and b^7, between each pair of the electrodes. It will be evident that when the electrodes, a^6, compresses the resistance material, a^7, the corresponding electrode, b^6, will reduce the pressure upon the material, b^7, so that the effects of the two halves of the double transmitter are always opposite to each other, one strengthening the primary current in its circuit when the other exerts the opposite effect. The connections to the primary windings on the induction coil are made accordingly, so that the two cores will be strengthened or weakened simultaneously, and not act against each other. According to the inventor, this arrangement produces a more faithful reproduction of pitch, loudness and quality of vocal sounds than the ordinary arrangement. Patent No. 723,016.

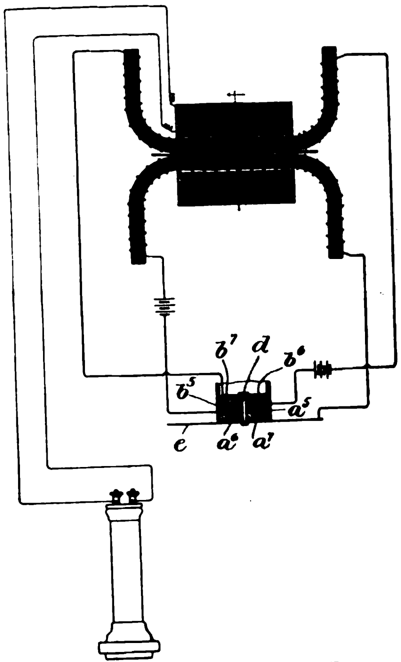

FIG. 2.—INDUCTION COIL.

Current-Collecting Trolley.—Since the application of electric traction to heavy-duty interurban roads, it has been a problem of considerable magnitude to provide sufficient contact surface between the trolley and the overhead line, where this form of construction is used. In some cases it has been found necessary to use two separate trolley stands, poles and wheels in order to obtain anything like satisfactory electrical results, but this arrangement has the obvious disadvantage that the forward trolley is awkward to get at for restoring it to the wire after it has lost contact. One method of solving the problem has been advanced in the form of a patent by Charles A. Terry, of the Westinghouse Electric & Manufacturing Company, and is illustrated

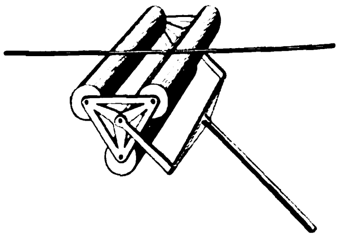

FIG. 3.—CURRENT-COLLECTING TROLLEY.

by Fig. 3 herewith. The trolley consists merely of three rollers, or sets of rollers, pivoted between two triangular frames, which are in turn pivoted at their centers to the trolley fork or harp. The trolley stand is mounted rigidly on the car instead of being revolvable, and the rollers are long enough to take care of lateral travel. This arrangement obviously doubles the amount of contact surface as compared with any single form of trolley, and also reduces to a much lower degree the probability of an absolute break in the contact between the trolley and the wire, in case the former should strike against a displaced hanger or section insulator. Patent No. 722,772.

Convention of the American Electrochemical Society.

The second convention of the American Electrochemical Society was held at New York City, April 16 to 18, and was a conspicuous success from every point of view. In every respect it fully justified Dr. J. W. Richards' closing remarks in his presidential address: "Does not each of us go away from these meetings feeling that he has been sharing in the views of all his electrochemical brothers, and with his mind so filled with suggestions, thoughts and ideas of what may, can and will be done in the near future, that he wishes he had a dozen lifetimes at his command in order to work out to realization this plentitude of ideas? Such is the zeal and ardor which our meetings engender in a high degree, from listening to papers and discussions, by conversations, by simple hand-shakes and seeing our friends, and by breathing the invigorating atmosphere of our assemblies."

The meetings were held in the Assembly Hall of the Chemists' Club. Space limitations prevent more than the very brief outlines of the papers which are given below.

Constant-Voltage and Constant-Current Separations.

The author, Dr. W. D. Bancroft, of Cornell, pointed out in this paper a general rule of classification for the numerous methods given in text-books on electro-analysis. He called attention to the fact that there are used in practice two essentially different methods for separating metals from other metals; according to one method it is the voltage which is kept constant, while by the other it is the current. Since the electrolytic separation of two metals depends on the fact that one precipitates at a lower voltage than the other, it would seem as though the proper way to effect a separation is to hold the voltage at a value such that the second metal cannot precipitate. This method has the advantage that the current drops to a very low value as soon as the first metal is completely precipitated, thus giving an automatic indication of the degree of precipitation. As a matter of fact, however, this constant-voltage method is not used in most of the standard separations, which are rather to be classed as constant-current separations, even though the current may not be held absolutely constant. If in such a constant-current method the second metal contained in the solution be prevented from being separated, it is of course necessary that at the end of the separation when the solution becomes poor in the first metal, something else is deposited from the solution together with the first metal instead of the second metal; this something else, which should not change the results, in practice is hydrogen. The essential supposition, therefore, under which a constant-current separation becomes possible is that the decomposition voltage for hydrogen in the solution used shall lie below the decomposition voltage of one of the two metals.

Since most separations were originally made without a voltmeter in circuit, no satisfactory results were obtained until a solution was found which permitted of a constant-current separation, and for this reason all except some of the most recent separations are constant-current separations. The order in which the different metals and hydrogen are deposited from a solution with increasing voltage, is, therefore, of the greatest importance. Dr. Bancroft gave tables showing the order of the metals deposited from solutions of sulphates or chlorides, cyanides, oxalates, phosphates and tartrates. In another set of tables he gave a summary of the majority of the separations for silver, mercury, copper, bismuth, tin, lead, nickel, iron, cadmium and zinc. If hydrogen is evolved before the second metal, the constant-current method is feasible and is used in practice; otherwise constant voltage must be used. From the tables it appears that this rule is generally correct (with a few exceptions which are explained in the paper) and that the overwhelming majority of the usual electro-analytic separations can be run at constant current without reference to the voltage.

Experimental Study of Some Electrode Effects.

In the absence of the author, Dr. H. T. Barnes, of Montreal, this paper was read by Dr. Bancroft. The author pointed out that in electrolytic experiments two apparently equal platinum electrodes never behave alike; the same is the case with other metals. The disturbing factor appears to be the air, which is dissolved in the solution, and the presence of air dissolved in the solution seems to be of greater importance even than any air dissolved in the electrodes. Various experimental facts were cited in support of this view.

The Electrolysis of Water.

Dr. J. W. Richards and Mr. W. S. Landis gave in this parer the results of a rather extended series of experiments, one of the most interesting of which was made with a closed vessel, completely filled with the electrolyte. A very thick, strong glass tube was used, filled with dilute sulphuric acid, which had been carefully boiled previously in order to get rid of the gases. The ends through which the platinum wire electrodes were introduced were sealed. Although an e.m.f. of 3.3 volts was applied, no current whatever was found to pass through the solution, but as soon as the seal was broken the current passed. The authors then described several experiments made to test Thomson's rule. In one the e.m.f. and currnt were carefully measured and at the same time the Joulean heat was determined by the rise of temperature, measured with a thermometer. From these data the decomposition voltage was found to be 1.49, in accordance with Thomson's rule. In another set of experiments the cathode was observed by a microscope in order to detect the formation of gas bubbles, while the voltage was gradually raised in steps of 0.05 volt. At 1.45 volts no gas bubbles could be detected, while they appeared at 1.5 volts. The authors finally investigated the so-called residual current (Reststrom). Current passes with any applied voltage below the proper decomposition e.m.f., the amount of the current increasing with the voltage. The concentration of the sulphuric acid used makes very little difference, but the amount of the current depends largely upon the quantity of the gases dissolved in the electrolyte. The limit is reached when these gases (which act like depolarizers) are used up; then the proper residual current sets in. The authors further made experiments with the electrodes 8¾ meters apart, and in another case a small fraction of a millimeter apart in the first case there was absolute conformity with Ohm's law, but not in the latter case.

The paper was discussed at length by Messrs. Bancroft, Bigelow, Burgess, Cowles, Hering, MacNutt and Reed. Mr. Hering doubted the suitability of platinum electrodes for such experiments and would have preferred gold electrodes. Mr. Reed referred to some old experiments of Faraday from which he concluded that above a certain voltage there is electrochemical decomposition, while below this voltage there is metallic conduction. Professor Burgess gave an account of experiments made by him on the influence of the pressure on the e.m.f. Dr. Bancroft doubted if the experiments of the authors were exact enough to say that Thomson's rule is strictly correct, and added that we have absolute evidence that it is not exact.

Experiments With Metallic Diaphragms.

This paper was by Dr. Bancroft, and in it the author described some experiments in which metallic plates were interposed between the anode and the cathode in a solution. In this case one may have anything between the two extremes, with all, or practically all, of the current passing through the diaphragm, and practically none of the current passing. When the diaphragm fills the cross-section completely, all the current must pass through it, and in order to pass a current, an excess voltage is necessary due to polarization, if the diaphragm does not behave as an absolutely reversible electrode. If the diaphragm does not divide the electrolyte into two detached compartments, no current will flow through it, unless it requires a smaller expenditure of energy than necessary to make the current flow through the electrolyte. Since the resistance of a metal plate is practically always less than the resistance of an equal thickness of electrolyte, current will always pass through an interposed plate unless prevented by polarization. If the thickness of the interposed plate be sufficiently great, the sum of the potential drop in the plate and the polarization may be made less than the fall of potential in the liquid, and current will then pass through the diaphragm. The author experimented with a thick carbon plate interposed between anode and cathode in a copper sulphate solution, in order to ascertain the exact conditions under which there is precipitation of copper on the side facing the anode. When the fall of potential between the ends of the carbon plate, as measured on copper wires dipped in the electrolyte, is less than one volt, there is no precipitation of copper. When the fall of potential exceeds 1.4 volt, there is a rapid precipitation of copper on the end of the carbon plate nearest the copper anode. On passing a current for a long time, there was a slight deposit of copper even when the difference of potential was only 1.1 volts, i. e., below the e.m.f. required for decomposition. He then experimented with platinum, and in order to avoid using plates of great thickness, he used two movable platinum electrodes connected metallically outside the solution; he had expected that this would be equivalent to a massive platinum bar, but this proved not to be the case. Instead of one electrode being anode and the other cathode, each electrode behaved to a certain extent both as anode and as cathode.

The Protective Action of Zinc Chloride on Metallic Iron.

In this paper Mr. Chas. J. Reed related some facts which he thinks are not in agreement with the dissociation theory. It is now generally recognized that the rusting or oxidation of metallic iron in the presence of water and saline solutions is an electrochemical process, the water or saline solution being the electrolyte and the metallic iron the anode. Small particles of graphitic carbon and other impurities or alloys serve as cathode to form local voltaic circuits. According to the dissociation theory, this attack of iron in a chloride solution would be due to the chlorine ions and should take place in a zinc chloride solution in the same manner as in a sodium chloride solution. He found that iron nails placed in a zinc chloride solution did not rust in any case; in strong zinc chloride solutions which had been boiled with metallic zinc and contained no free acid, there was not the slightest action of any kind upon the iron.

The first paper of the afternoon session dealt with

Insulating Materials; A Field for Chemists,

in which the author, Dr. M. von Recklinghausen, pointed out that chemists are indebted to electrical engineers for the great advantages of the use of electric power, and should show their gratitude by studying the problem of devising an electrical insulating material which is good all around. Chemists sometimes offer materials for insulation which may have one good property; for instance, may have enormous resistance to the passage of a current, but may be so highly inflammable or may have such a low melting point as to be utterly useless for the purpose intended. The author gave a systematic review of the desirable and undesirable qualities of the prominent insulating materials used nowadays; the desiderata are good insulation resistance, high disruptive srength, and good mechanical properties, especially workability; faults are combustibility, a low melting point, and changes of the electric and mechanical properties, with rise of temperature or with age, and, of course, high price. He briefly reviews the different materials which come into consideration. Of liquid organic compounds oils are the most important; their disadvantage is their combustibility. It has been proposed to use halogen carbon compounds, instead of hydrocarbon compounds. Among the organic compounds used in a solid and more or less plastic state there are varnishes, lacquers, drying oils, rubber, cellulose materials, etc. Most of them have very undesirable qualities. The pure cellulose compounds are probably very good in most respects, and seem to be less affected by heat and less inflammable than other materials of this group; but up to now they are fairly difficult to get into the desired dense mechanical shape. Mixtures of asbestos or mica with varnishes, rubber or similar materials mostly lack flexibility and mechanical strength. Inorganic solid materials, like slate, marble, asbestos, porcelain and glass, lack flexibility. Progress is probable in the line of cements that can be molded, although up to now they seem to be too hygroscopic. A tremendous step forwards would be a material of the flexibility of asbestos and the ideal high insulating and dielectric strength of mica.

A Historical Review of the Storage Battery,

was the title of a paper read by Mr. H. B. Coho. As it was a review of the development of the storage battery industry, with brief and concise references to its various phases, it is impossible to give a brief abstract of the paper. In the discussion which followed, Dr. H. S. Carhart related that in 1881 Planté told him he had tried to apply by mechanical means the active material on the plates, but had found such plates did not give as good results as plates formed electrochemically.

The Use of Pyroxyline in Electric Storage Batteries,

A paper on this subject was presented by Mr. Elmer A. Sperry. After some general remarks on the inherent weakness of the positive plates of the lead storage cell, he discussed the use of a pyroxyline envelope which is wound around the plate, passing down one side, under the bottom of the plate and up the other side. If any active material should be loosened accidentally, it is thus prevented from dropping off, being held in its position by the pyroxyline envelope. This cover is made of open-mesh cotton cloth, such as cheese-cloth, which is chemically treated, forming a cellulose nitrate, termed "pyroxyline," of the same general character as gun cotton. Batteries with pyroxyline envelopes have been in continual use for three years and proven entirely satisfactory. The initial difficulties which were experienced in the manufacture of the pyroxyline envelope have been entirely overcome. The paper was briefly discussed by Mr. C. J. Reed. Mr. Sperry remarked that the pyroxyline cannot be used on the negative plate.

The Concentration Changes in the Electrolysis of Brine.

In a paper on this subject, Dr. W. H. Walker discussed the results of experiments recently published by C. T. Townsend in *Electrochemical Industry*. Dr. Walker showed that the results observed by Mr. Townsend can be simply explained by means of the migration of ions, and that the resulting concentration changes can be calculated from Hittorp's transport numbers.

Thermo E. M. F. Without Difference of Temperature.

In this paper Professor H. S. Carhart presented a very clear and simple thermodynamical theory of concentration cells and of galvanic cells in general. The Peltier effect is a single example of a very general law; if a current passes through a junction, energy is either given to the circuit or taken from it. The flow of the current produces a difference of temperature. These temperature changes have nothing whatever to do with the Joulean heat. Professor Carhart pointed out the essential difference in the behavior of a circuit, consisting of metals only, and of a circuit consisting of both metals and electrolytes. He then showed how the Carnot-Clausius thermodynamic cycle can be applied to the theory of a galvanic cell.

Mr. A. A. Knudson then read a long paper on

The Corrosion of Metals By Electrolysis.

The author first took up the subject of electric currents generated in the earth by local circuits formed by different metals in contact with another and with the damp earth acting as electrolyte. An analogous case is the corrosion which often takes place in vessels, due to galvanic action If, when repairs become necessary, iron patches are bolted over the copper-plated hull of a vessel, corrosion is bound to follow. A still more important case of sea water corrosion due to placing together dissimilar metals, is sometimes found on the propeller shafts of steamers. The author then discussed the electrolytic action of the return currents of electric railways upon gas and water pipes, as well as upon metallic structures, such as bridges.

The paper was discussed at some length by Mr. Carl Hering, who pointed out that the corrosive effect on pipes depends upon the current flowing in them, and that in very many cases it is absolutely wrong to judge from voltmeter measurements what this current may be. He suggests to measure the current in a pipe as follows: Connect two points of the pipe with both an ammeter as well as with a voltmeter and take a reading of the ammeter and of the voltmeter; disconnect the ammeter and take another reading of the voltmeter; then the current in the pipe is given by a very simple formula, which may be easily found by using Ohm's law. Mr. Hering suggested to apply the following remedy at such points of iron pipes where electric currents are tending to leave them and thus to destroy them by corrosion. Connect at such places the iron pipes with a block or plate of zinc; then the currents will not pass from the iron directly into the earth, but first into the zinc and the corrosion of the iron is thus prevented; the zinc is, of course, gradually eaten up. It may pay to prevent the corrosion of iron docks in the same way, by connecting them with a block of zinc. Mr. C. J. Reed mentioned that the same remedy of the use of zinc is being applied and has proven very satisfactory on steamships to prevent the destruction of condenser tubes.

FRIDAY, APRIL 17.

The first paper of the second day's sessions was one on

The Composition of Electroplating Solutions,

by Dr. N. S. Keith, in which the author pointed out that electroplating and electrotyping the anodes should be of the pure metals; otherwise if the impurities be metals electropositive to that which is transferred, they will either enter the electrolyte, thus changing its constitution by the introduction of undesirable salts; or they may, if insoluble, form crusts on the anode, consisting of insoluble and non-conductive salts. The ideal electrolyte wherein metal is to be transferred is a solution of that metal which has no corroding effect on either the anode or the cathode when no current is flowing through the cell. Such a solution may possibly be made; but in operation, when current passes, it can be maintained only with difficulty. The author suggested the use of strong solutions with abundant solvent of the salt formed at the anode and rapid circulation; under such conditions high current densities may be used and deposits are rapidly obtained. The author discussed especially gold and silver plating and finally referred to his process of refining lead base—bullion, separating its contents of gold and silver by electrolysis. The general tendency in electroplating solutions in operation is to form oxy salts at the anode. This is undesirable and, if avoided, either by suitably composing the solution, or by properly operating it, the best results will be attained.

In the discussion which followed Mr. H. E. Heath spoke on the use of unipolar machines for electroplating. Mr. C. O. Mailloux then gave an extended and interesting account of experiments made by him some years ago in electroplating. He described how he had developed a plating process by careful and systematic laboratory work and how it became an easy matter to get very good deposits with a current density of 500 amperes per square foot, thus shortening the time of the process very considerably.

Determination of Vapor Densities in the Electric Furnace,

was the subject of a highly interesting paper read by Dr. Walther Nernst, of the University of Göttingen, Germany. The method employed is the classic one of Victor Meyer, which heretofore could not be used at temperatures higher than about 1800° C. It is now possible to use the same method for temperatures of about 2000°, by using apparatus of iridium, which has a melting point of somewhat over 2200°. Heræus, of Hanau, succeeded in making a small but expensive apparatus. The reading is taken by measuring the motion of a mercury meniscus. Small egg-shaped vessels of iridium are used to contain the substance, and the weighings are made on a specially devised torsion balance. From some examples quoted by Dr. Nernst, it appears that the method is surprisingly accurate. The author's achievement was highly commended in the discussion by Messrs. Bancroft, Backeland and Richards.

Note on Electrical Endosmose.

A brief paper was then read by Dr. W. D. Bancroft on electrical endosmose or cataphoresis. The author pointed out the great importance of this phenomenon for scientific as well as technical work. It should not be neglected, as is generally done; it may in some cases be even more important than the effect of the true migration velocities of the ions. It is of importance to know that it is possible by proper choice of the diaphragm to obtain the degree of endosmosis wanted for the special purpose.

Ions and Electrons.

Dr. Louis A. Parsons, of Johns Hopkins, read a paper on this subject in which he gave a review of the work of various investigators, especially J. J. Thomson, which led to the modern conception of electrons, and discussed the relation between electrons and ions. As the first part of the paper was a concise summary of the historical development of the electron theory, and as the second part was highly mathematical, it is impossible to give a brief abstract of the paper.

Uniformity in Electrochemical Equivalents.

A brief paper on this subject was read by Mr. Carl Hering, who suggested that, for the sake of uniformity, electrochemists should adopt a combination of certain values already adopted by authoritative bodies. They are the electrochemical equivalent of silver 0.001118 gramme per coulomb, and the table of atomic weights issued by the American Chemical Society. This leads to a change of a univalent gramme ion of 96,538.5 coulombs, or approximately 96.540 coulombs, which is already widely in use In the discussion Dr. Bancroft remarked that from recent measurements of J. W. Richards it seems that 96,600 coulombs is more correct than 96,540.

E.M.F. of Alloys.

A brief note was then presented by Dr. W. D. Bancroft on the e.m.f. alloys with respect to one of the two metals. He pointed out an apparent anomaly and explained it by showing that it was due to the fact that in such abnormal cases there is no chemical equilibrium.

SATURDAY, APRIL 18.

Electrolytic Production of Metallic Compounds

The first paper on the final day was a long one by Prof C. F. Burgess and Mr. Carl Hambüshen, of the University of Wisconsin, on the above subject. The authors point out the limitation of the methods at present available and deal with some of the difficulties which must be encountered in large scale working. The suitable design of electrolytic apparatus requires special ingenuity and skill of the designer. The advantages of electrochemical methods over purely chemical methods are pointed out in various special cases. The authors gave an account of an extended series of experiments in which they tested various processes for the production of white lead; they reached the conclusion that there is little chance for the electrolytic process replacing the chemical methods at present. In the production of various other lead compounds, however, there seems to be greater opportunity for commercial application of the electrolytic method, and lead acetate, lead chloride and lead chromate may be produced to advantage by electrolytic methods

The Electro-Deposition of Metals Upon a Rotating Cathode.

A paper on this subject by J. G. Zimmerman was then read by Professor Burgess. The result of the investigation is that the use of high-current densities in depositing metals is made possible by the us of rapidly rotating cathodes. The critical current density, i. e., that at which a powdery deposit occurs, is approximately proportional to the speed of rotation. In the case of nickel plating, particularly, this method has great advantages, as it is possible to obtain a much thicker coating of nickel when the cathode is rotated than when stationary. Zinc behaves quite differently from nickel. Increase of current density by means of rotating cathodes is also possible in the case of iron, lead, antimony and silver. In the ensuing discussion Mr. Hering suggested that a strong circulation of the electrolyte would have the same effect as rotating the cathode.

Electrolytic Conduction Without Electrodes.

A paper on this subject was read by Mr. A. B. Marvin . He described several arrangements based upon the principles of dynamo construction and designed to detect electrolytic conduction without any electrodes. The best results were obtained with an apparatus consisting essentially of two alternating-current transformers of somewhat peculiar construction. The primary of the first was excited from a 125-cycle alternating-current power circuit. Its secondary winding, which consisted of a tube of electrolyte, served also as the primary of the second transformer, and the secondary of this second transformer was connected to a telephone receiver. Thus the impulses induced in the core of the first transformer were transmitted through the electrolyte to the core of the second and thence to the telephone. Whether decomposition of the electrolyte takes place is not definitely determined, but probably it does not.

Notes on the Electro-Deposition of Nickel was the subject of a paper read by Mr. Woolsey McA. Johnson. The author gives in this paper some extensions of his notes given in a recent number of *Electrochemical Industry*. He discusses at some length the reasons why hot solutions are used in processes. It is quite possible to obtain good deposits from cold solutions, but for certain commercial reasons which are explained by the author, the use of a hot solution is advantageous. In the second part of his paper the author discusses why the use of a hot electrolyte prevents the curling of nickel deposited at high-current density. He suggests that this fact is directly connected with the formation of nickel-hydrogen alloys.

Notes on Modern Electrolytic Copper Refining.

Mr. Titus Ulke's paper on this subject was read, in the absence of the author, by Dr. J. W. Richards. Mr. Ulke suggests that the managers of copper refineries might profitably adopt the methods of the American iron and steel makers and allow engineers free access to all parts of their plants and thereby encourage a free exchange of ideas and the obtaining of mutual benefits. All the so-called mysteries of electrolytic copper refining may be resolved into certain more or less well-known simple rules of practice. The material at present subjected to profitable electrolytic treatment in electrolytic refineries is invariably a precious metal bearing crude copper cast into anodes, assaying at least 96 per cent. copper and generally refined by fire methods up to 98 or 99 per cent. The initial cathode sheets are invariably thin sheets of electrolytic copper, obtained by deposition upon the stripping from greased, oiled plates of copper or lead. The constantly decreasing acidity and the constantly increasing copper contents of the electrolyte must be maintained within certain limits. Heating the electrolyte up to 40° or 50° C. is advantageous.

On the evening of April 16 a subscription banquet was held in the hall of the German Liederkranz Society, which was handsomely decorated for the occasion. It was well attended and an extremely enjoyable affair.

On the afternoons of April 17 and 18 various visits were made to local establishments of interest, the list of which included the Sawyer-Man Electric Company's works, the store of Eimer & Amend, the laboratories of Cooper Union, the Willyoung & Gibson Company, the Crocker-Wheeler Electric Works, a galvanizing plant installed at the Brooklyn Navy Yard by the United States Electro-Galvanizing Company, the Edison station at Thirty-eighth Street, the Manhattan Railway Company's power house at Seventy-fourth Street, the Metropolitan Street Railway Company's power house at Ninety-sixth Street, the new Rapid Transit Tunnel at Fifty-ninth Street and Broadway, Columbia College and the New Jersey Zinc Works.

At the election of officers held during the convention, the old officers and directors were re-elected. These are Dr. J. W. Richards, president; C. J. Reed, secretary; P. G. Salom, treasurer; Dr. W. D. Bancroft, Dr. C. A. Doremus and Dr. W. R. Whitney, vice-presidents; Col. S. Reber, Dr. S. T. Sadtler and Mr. C. O. Mailloux, managers.

NOTES.

The American Street Railway Association.—will hold its twenty-second annual meeting at the Grand Union Hotel, Saratoga Springs, N. Y., on September 2, 3 and 4. Particulars concerning hotel accommodations and railroad rates are obtainable from Mr. T. C. Pennington, secretary of the Association, whose address is 2020 State Street, Chicago.

Summer School for Artisans.—The summer school established by the University of Wisconsin and conducted under the direction of the University's College of Engineering, opens on July 6 and closes August 14. The school was established for the benefit of machinists, metal workers, stationary or other engineers, shop foremen, superintendents of plants, power stations, etc., and others of similar classes. No detailed educational requirements are made for entrance, but each applicant is questioned with a view to ascertaining his fitness for undertaking the work. A fair speaking and writing knowledge of English and a knowledge of elementary arithmetic are necessary, however, in order to make the course profitable to the student. Full particulars concerning this course may be obtained from Mr. W. D. Hiestand, Registrar, University of Wisconsin, Madison, Wis.

The National Electric Light Convention.—A preliminary list of 125 questions has already been tabulated by Mr. Hartman, editor of the Question Box for the twenty-sixth convention of the National Electric Association, from questions already received from members, and Miss Billings, the assistant secretary, advises us that new questions are coming in daily. This feature of the programme will undoubtedly contribute greatly to the interest and importance of the meeting. Many of the questions relate to subjects that have never before been brought up for discussion at the conventions.

The Central Passenger Association has granted the usual special rate of a fare and a third, on the certificate plan, from all points in their territory to Chicago and return, for delegates attending the convention, which, as announced last month, will be held in Chicago, May 26, 27 and 28.

Philadelphia Branch of the American Institute.—The second meeting of the Philadelphia branch of the American Institute of Electrical Engineers was held Monday, April 6, at the Engineers' Club of Philadelphia. Mr. Carl Hering, the chairman, made a short opening address, and after the transaction of routine business, Mr. Hewitt presented Mr. P. O. Blackwell's paper on the "Testing of Insulators" and Mr. Ralph D. Mershon's paper on "Mechanical Specifications for a Proposed Standard Insulator Pin." Mr. P. M. Lincoln, of Pittsburg, presented and discussed a paper by himself on "Transposition and Relative Location of Power and Telephone Wires." Mr. H. H. Barnes, of Pittsfield, Mass., presented a paper on the "Burning of Wooden Pins on High-Tension Transmission Lines," written by Mr. C. C. Chesney.

Mr. W. L. Hodges, the chief engineer of the Keystone Telephone Company, gave a brief résumé of the New York discussion of Mr. Lincoln's paper. Mr. Hodges disagreed with Mr. Gerry's statement, that the ordinary telephone lightning arrester was an undesirable and unsafe piece of apparatus for properly taking care of telephone circuits. He said that he had had considerable experience with different types of arresters, and found some that answered admirably. He stated that it must not be expected that an ordinary lightning arrester should be sufficient in extraordinary cases. Mr. Hodges discussed the various difficulties liable to arise where telephone and high-tension circuits are run on the same poles, and came to the general conclusions that in order to get the best transmission and safety combined, (1) both the power and the telephone line wires should be properly transposed (and this transposing is not altogether as simple a matter as it is generally supposed, as it would be possible to arrange the transpositions so that the power and telephone wires would neutralize each other); (2) the insulation of the telephone lines should be high, and, of course, the line should be strongly constructed; (3) at each telephone station the instrument circuits should be connected to the secondary of a transformer, which transformer should have a high-resistance primary with a great number of turns, and high insulation between the primary and secondary. The middle point of the primary winding should be connected to ground through a retardation or choke coil. In each side of the telephone line circuit, at each station, there should be a so-called "lightning gap" arranged, designed so as to discharge when the potential of the telephone wires approximate that which would break down the insulation of the line. In the connection to ground of this lightning arrester, there should be placed an electromagnet of low resistance and low retardation, so arranged that by its operation it will open the telephone line between the arrester and the transformer and connect the ground side of the lightning arrester with the ground direct.

This method of construction, it will be seen, removes the objection that a workman would come in close proximity to the ground while working on the telephone circuit, and it also provides necessary protection for the telephone user without allowing a path for leakage of the telephone current or affecting the transmission by increase of capacity.

Mr. H. F. Sanville then gave an abstract of the New York discussions of the papers of Messrs. Blackwell, Mershon and Chesney.

The general discussion followed, during which a spirited controversy between Messrs. Lincoln and Hodges was carried on, regarding the electrostatic effect through a telephone receiver, due to the electrostatic effects of the main transmission line, Mr. Lincoln maintaining this is a constant current effect, and Mr. Hodges taking the position that it is a constant potential effect.

City Pumping From Central Stations.—A committe appointed by the Iowa Electric Association to obtain data on city pumping from electric central stations, submitted a most interesting report at the meeting of the Association held last month at Davenport, Iowa. A summary of the data contained in the report is given by the accompanying table, for which we are indebted to Mr. D. F. McGee, chairman of the committee. Mr. McGee's company (The Red Oak Electric Company) was one of the first in the State of Iowa to attempt city pumping, and its experiment has resulted in saving money for the city. The company's margin of profit, however, has not been very large.

Name of Company.	Population.	Steam or Electric Power.	If Electric D C or Alternating.	Voltage.	Size of Stand Pipe.	Owner of Apparatus	Day Power Circuit.	Minimum Charge Per Month	Per 1000 Gal Over Max-Amt.	Pres're Water	Coal Per Ton.	Kind of Fuel.	Cost of Apparatus.
Britt Elect. Power Co.	2000	Steam			5600 gallons	City	No	$35 Flat Rate		40	$2.00	Steam	$1400.
Buffalo Centre Elect L and P Co.	780	Steam			20x22 feet high	City	No	$50 Flat Rate		30	2.50	Steam	4400
Lea Electric Co., (Clarinda)	4000	Steam and Electric			100,000 gallons	City owns Pump	No	$145 per 100,000 gal-day	5 Cents	65	2.00	Steam	1400
Clear Lake Electric & Power Co.	1800	Steam			12 diameter, 80 high	City	No	$50 per 28,800 gal pr day	6 Cents		1.90	F Steam	Not Given
Denison Electric L & P Co.	3000	Steam			16 diameter, 60 high	City	No	44,000 per day	6 Cents	95	2.05	Steam	Not Given
Dewitt Electric & Power Co.	1500	Steam			47,000 gal tank		No	25,000 per day	9 Cents	35	2.77		$1000
Decorah Electric Light Co.	5000	Electric	25 H P Direct	500	300,000 gal reservoir	Company	Yes	$150, 112,000 gals pr day	4 Cents	100	4.25	Lump	2000
Knoxville Electric Co.	3500	Electric	85 H P Direct	220	10 diameter, 112 high	City	Yes	$50, 20,000,000 per year	3 Cents	52	1.00	Steam	Not Given
Lake Mills, (J. C. Conley)	1600	Steam			1300 barrels	City	No	$41.67	None	40	2.45	Steam	Not Given
Logan Electric Co.	1500	Steam			Direct pressure	City	No	$840 per year	None	100	1.75	Pea Coal	$1000
Lake City Electric Co.	2800	Steam			12 diameter, 80 high	Not Stated	No	$800 per year	None		2.40	Mine Run	Not Given
Marengo Electric L & P Co.	2100	Steam			2000 bl tank on 100 ft tower	City	No	$50 per month	60c p'r hr for Ex Am't	50	1.40	Steam	Not Given
Malvern Electric L & P Co.	1500	Steam			1200 gallons	City	Yes	$60 per mo, 4 hrs a day		10	2.25	Mine Run	Not Given
Northwood Electric Co.	1400	Steam			20x24 tank with 100 ft tower	City	No	$30 per month		48	3.25	Centerville Blk	$800
Red Oak Electric Co.	6000	Electric	45 H P Direct	500	238,000 gallons	Company	Yes	$125 mo 100,000 gal-day	4 Cents	100	1.90	Steam	2500
Rockville Electric L & P Co.	2000	Steam			12x100	City	No		10 Cents		1.96	Mine Run	400
Sac City Electric Co.	1800	Electric	2 phase 15 H P Induction	400	10x100	Company	No	$81 per mo, 900,000 gals	5 Cents	75	2.15	Nut Mixture	2000
Tipton L & H Co.	2500	Steam			Size not given	City	No	$150 per month	Flat Rate		2.25	Steam	Not Given
Traer Electric Co.	1500	Steam			72,000 gallons	City	No	$60 per month	Flat Rate	55	1.70	Steam	Not Given
Villisca Electric Co.	2500	Electric	2 phase 20 H P	440	20x20 tank	Company	Yes	$80 mo, 50,000 gals day	4 Cents	67	1.52½	Steam	$1100

Instructions for Motormen.—An editorial writer on the *New York Times*, discussing recently a manual published for the instruction of street railway motormen, suggested that the following humorously expressed but far from nonsensical rules should be included among the instructions issued to motormen:

"(1) Keep one hand on the controller and the other on the brake handle. Each may have to be thrown into action very quickly, by revolving them in opposite directions. If nature has not endowed you with a double-barreled mind, you would do well to spend as much as possible of your time off duty in learning to describe circles in the air with both hands simultaneously turning them in opposite directions. This will be good exercise and have the incidental advantage of entertaining the children.

"(2) One leg must be kept free of other engagements to actuate the gong. Practice in the waltz step will be useful in giving the elasticity and flexibility to the ankle which rapid and continuous gong ringing demands. No specific duties are assigned to the other leg, and it will be found useful to stand on. If you are grateful for mercies enjoyed, . . . some part of your leisure may be employed in giving thanks that you lack the equipment of a prehensile tail, or something would be found for that to do which would further subdivide your attention.

"(3) Do not deem it part of your duty to maintain a flirtation with an attractive young woman if she chances to be seated near the front of the car. . . . It is distracting, and you have enough to attend to without it.

"(4) It is not wise to see how near you can come to an obstructing or crossing vehicle without hitting it. Your judgment of distances and relative speeds may not be inerrant. Of course you should have a clear right of way, but this is not always possible, and taking the chances of facilitating the clearing of it by impact when obstructed is expensive. It may cost you your job.

"(5) If you find it necessary to swear at the conductor, do so in an undertone. It will have just as much value and the passengers will be better pleased. To follow the bell involves less responsibility than to keep an eye on the rear end of the car to make sure that your colleague is attending to business.

"(6) It is exceedingly good fun to grind a hack or a private carriage between your car and an elevated railroad pillar, and the chances are that the blame will fall chiefly on the driver; but it does not further the interests of the company to do this often, and it would be wiser to enjoy yourself in other ways.

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CONTENTS.

Isolated Plant of the Edward Ford Plate Glass Company, by J. R. Cravath 211
Some Difficulties of Long Distance Electric Transmission, by Paul M. Lincoln 212
Telephone Engineering, by F. J. Dommerque 213
Mechanical Draft, by Charles L. Hubbard.. 215
Tests of a Belgian Engine 217
Pipe Coverings, by R. T. Strohm 221
Abstracts from Foreign Contemporaries 223
Some Recent Electrical Patents 226
Convention of the American Electrochemical Society 227
Notes 230
Editorials 232
Simple Form of Circuit-Breaker, by S. M. Kintner 234
Oiling System for Power Plants, by P. E. Moock 235
Automatic Telephone Systems, by A. Dallam O'Brien 236
Failure of Direct-current Dynamos to Generate, by E. C. Parham 238
Lessons in Practical Electricity 239
Letters on Practical Subjects 240
Electrical Catechism 241
Queries and Answers 242
Lamp Holder for Photometers, by J. C. Fish 243
Small Plant Switchboards 243
The Curtis Steam Turbine 244
New Apparatus and Appliances 245
New Book 250
Obituary 250
Personal 250
Trade Publications ....Adv. 57
Business News ....Adv. 57

City Pumping by Central Stations.

The Iowa Electrical Association is carrying on excellent work in collecting data on various subjects connected with central station practice from the lighting stations of the state. One of the most important reports made at the recent convention of that association held at Davenport was that giving data on the pumping for city water works by central stations, which is reprinted on another page. The report shows that twenty companies do city pumping, and it developed at convention that there are several that did not report. Fifteen of the companies which rendered reports have the pumps located in the power house and operate them directly by steam; five are using electric motors to drive the pumps. The latter class is probably most interesting because it is by the use of electrically-driven pumps located some distance from the station that existing electric light plants can most readily take over the operation of existing water works pumping stations now operated independently by steam.

The minutes of the Iowa convention showed the gratifying fact that the pumping of city water by electric pumps is rapidly on the increase, as it rightly should be, since a lighting and power company ought to be able to do this pumping considerably cheaper than the city would do it with a separate steam plant to operate and maintain. The report from the Iowa stations and the discussion in the convention seems to indicate that in most cases the contract for city pumping has been taken by the electric light companies at too low rates. The obvious moral is that electric light companies should not be so anxious to get the city pumping contract as to give the city all of the saving resulting from the change and leave no profit for themselves. The situation is usually such that both the city and the company can profit by discontinuing a relatively small pumping plant and doing the work by means of motors driven from the lighting station during periods of small load. The prices and conditions given in the report are, of course, so variable that no general conclusions can be drawn from them save that just mentioned, that many of the contract prices are lower than is either necessary or advisable.

Roughly speaking, it may be said that the actual coal consumed when the pumping is done electrically by the central station will be about the same as when a separate steam pumping plant is operated, provided the steam pumping machinery is of good efficiency. The greatest saving is in attendance when electrically driven pumps are used, and there is also a considerable saving in repairs.

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Induction Motors for Multiple Speed Work.

The difficulties involved in providing multiple-speed induction motors have been several times referred to and explained in a general way in these columns, and it is a real pleasure to be able now to say something on the other side. In direct-current work requiring continuous operation at any one of several speeds, it has become quite common to secure wide speed ranges by providing several impressed voltages. This method is not applicable to alternating-current work, because variations of the impressed e.m.f. do not affect the speed of a motor within practical limits, and only disastrously when they affect it at all. But the number of stator or field-magnet poles and the frequency of the alterations of the supply current control the speed absolutely. The expedient of using field-pole permutation in order to obtain several speeds is, of course, old, and has been applied in a number of instances. But the practical disadvantages are such that this method is available only to a very limited extent. By combining field-pole permutation with a plurality of impressed frequencies, however, one may obtain a range of speeds fairly comparable to the direct-current range, except as to gradations between the "fundamental" fixed speeds. Such a combination has been put into practice in the plant of the plate glass works briefly described in our leading article this month, and is reported to give entirely satisfactory results.

No great complexity is entailed by winding the primary of an induction motor so as to obtain two speeds of a ratio of 2 to 1 by means of changing the connections of the windings. This is directly analogous to the result primarily obtained by putting two windings and commutators on a direct-current motor. The speed and power are varied in the same ratio in both cases. Additional speed rates may be obtained with the alternating-current system, of course, by providing several frequencies. With frequency sources of 20, 25 and 30 cycles, there could be obtained also 40, 50 and 60 cycles without serious complication, and these frequencies combined with 2 to 1 field-pole permutation on the motor would give a speed range of 6 to 1, in very convenient steps, the greatest "jump" being 25 per cent., in passing from 20 to 25 cycles. Unfortunately, no gradation is practicable between the several successive speeds fixed by the frequency, such as that obtained by regulating the field excitation of a direct-current motor. Then again, the provision of a combination frequency changer to give different frequencies in different circuits would be expensive, since frequencies cannot be added, like direct-current e.m.fs., merely by combining two or more in series. The problem appears to be a very attractive one, however, and the development of some economical means of converting a single alternating-current frequency into several others and varying the latter individually through a small range would undoubtedly justify a very large expenditure of time and money. The accomplishment of this result in a practical manner would put the induction motor substantially on a level with the direct-current motor for machine tool and other multiple-speed driving.

Municipal Ownership Argument.

With the high-sounding title of "The Lighting Monopoly of New York City and Its Exactions," the Merchants' Association, of New York, has issued a folder purporting to give "some reasons for a municipal lighting plant." The association's "argument" is as loose-jointed as its grammar. Divested of a mass of irrelevant semi-socialistic whining about the over-capitalization of an alleged rapacious monopoly, the "argument" reduces to the statement that the city of New York pays more for its light than other cities. Why shouldn't it? Has any member of the Merchants' Association who owns real estate been heard to mourn over the fact that residents of New York pay higher rents than those of any other city in the world?

In every case of agitation for municipal ownership of which we have had knowledge, the movement was due directly to superfluous zeal on the part of incompetent "reformers" serving unwittingly as cat's-paws for self-seeking or ignorant demagogues. The present case gives strong indications that it is of the same class. The stand taken by the present municipal ownership advocates is that because the price charged New York City is $146 per annum for the service from each arc lamp, while the average price paid elsewhere ranges between $80 and $85, a municipal plant should be built at once. It doesn't matter that the cost of installing a single mile of underground lines in New York costs as much as the whole wire plant of one of the $80-per-lamp stations. It is also unworthy of consideration that Boston almost offered to give away its municipal plant and now pays $125 per lamp, and that San Francisco, Philadelphia and New Orleans all pay over $100, while Baltimore pays $99, notwithstanding the low rates enjoyed by Evansville, Ind.; Saginaw, Mich; Toms River, N. J.; Pulaski, N. Y., and other metropolitan centers. The prime facts are that the New York Edison Company is a grasping octopus and its service costs the city $146 per lamp—never mind what the cost of production may be. This is truly a sound, analytical and business-like "argument" on which to base an appeal for a municipal lighting plant.

Tests with Superheated Steam.

The results of tests recently made with a Belgian engine using superheated steam, which are given in full elsewhere in this number, go far toward vindicating the enthusiasm of superheat advocates by reason of their approximate agreement with other tests made independently on different sizes and types of engines. The tests show that with 253 degrees of superheat (at the valves) an addition of 8.9 per cent of heat units per pound of steam produced an in- of superheat an addition of 12½ per cent per pound of steam, while with 343 degrees of superheat an addition of 12½ per cent of heat resulted in an increase of about 35 per cent in the work done per pound of steam. The general results of the present tests are somewhat more conservative than those obtained by Prof. J. A. Ewing some time ago near Amsterdam, and later at Manningtree. In the latter tests, with 230 degrees of superheat an economy was obtained of 9 pounds of steam per indicated horse-power-hour; in the present tests this same economy was obtained, but with a much higher superheat. The engine, however, was operated at a slower speed than that tested by Professor Ewing. The general results of the two sets of tests are unusually close, considering the differences in the engines and conditions.

The rather startling showing of an increase of 2½ per cent to 3 per cent in work for each 1 per cent added to the thermal units by means of superheat was recently explained by Professor Ewing to be due to a vast reduction in piston and valve leakage and the elimination of the losses entailed by condensation and reheating. The latter feature is well known, of course, but the former is not. According to Professor Ewing, a tight valve or piston is impossible with moist steam because a film of moisture gets between the valve and its seat, and between the piston rings and cylinder wall, and allows leakage. With superheated steam this action is obviated.

Testing Power Plant Machinery.

A request has been received from a correspondent to the effect that we advocate separating tests of central station and isolated plant equipment into two general sections, one to cover the cost of evaporating the feed-water and the other to cover the generating economy of the plant, beginning with the steam in the boiler. We supposed that all tests made by careful engineers were thus subdivided, since this is the only method by which the efficiencies of different plants can be compared intelligently. It appears, however, from the communication referred to, that many so-called comparative tests of central station equipments have been made in terms of kilowatt-hours per pound of coal, or unit of expenditure for coal, without regard to the furnace, boiler and piping efficiency of each plant. Of course, such tests may be reduced to a common level by taking into consideration the cost per ton and calorific value of the different coals, and for rough comparisons of entire plants these will serve well enough.

Tests of power plants, however, are commonly made in order to determine the economy either of some one division of the plant, such as an engine, or a boiler, or of every component part of the plant. In the first case, of course, no over-all tests are made, only the part under consideration being tested. In the second case, it is impossible to obtain results from which one could determine just where the plant could be improved, without making the tests to show the calorific value of the fuel, the pounds of fuel burned per pound of water evaporated, the temperatures of the feed-water and the steam, the quality of steam delivered to the engine, the pounds of steam required by the engine per indicated and delivered horse-power-hour, and the kilowatt-hours at the bus-bars per horse-power-hour delivered to the generator shaft. It is readily conceivable that it might be desirable to make any one of these tests or any directly related group of them, but it is not easy to see how any advantage can be derived from making a "blanket" test for pounds of coal per kilowatt hour.

A SIMPLE FORM OF CIRCUIT BREAKER.

BY S. M. KINTNER.

To the inexperienced experimenter, perhaps no instrument or piece of apparatus causes such a feeling of security as a reliable circuit-breaker in the line. A fuse will generally blow in time to prevent any serious burning, but when a wrong circuit is closed, causing a large current to pass through an ammeter of small capacity, the damage to the pointer and moving parts due to the excessive deflection and overheating is done before the fuse has time to act. The writer's experience in dealing with students has caused him to realize the advisability of using a circuit-breaker in order to avoid accidents of this kind. While it is doubtless wrong in theory to relieve the student of the responsibility of using the instruments properly by allowing him to depend upon the circuit-breaker to save him in case of mistakes, it is a great relief to the nerves of the instructor to have a safety device of this kind in the circuit. Also students have a pride about burning fuses and throwing circuit-breakers that generally causes them to be reasonably careful not to make such noticeable blunders.

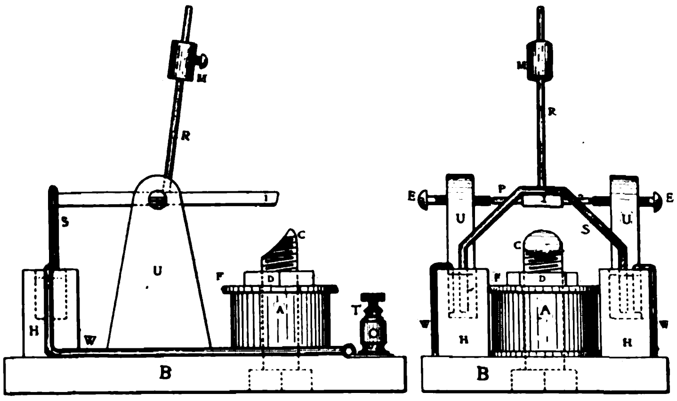

FIG. I.—SIDE AND END VIEWS OF CIRCUIT-BREAKER.—FIG. 2.

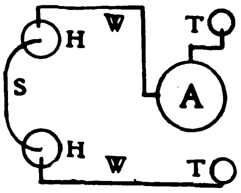

FIG. 3.

It is the purpose of this article to describe a simple form of circuit-breaker that has proved to be very satisfactory in operation in the laboratory of which the writer has charge. The points that have governed the design of this device are certainty of action, simplicity of parts and ease and cheapness of construction. In the design illustrated by the drawings all these points are well taken care of.

The action of the breaker may be readily understood by comparing the drawings with the diagram of connections. When the current reaches a certain value, the magnetic pull between the iron core, *C*, and the pivoted iron strip, *I*, becomes great enough to disturb the balance of the strip, *I*, and its system, and causes the circuit to be opened at the mercury cups, *H H*. The opening of the circuit is very quick and decided, with no hanging on of an arc of appreciable length. As soon as the balance is slightly disturbed, the weight, *M*, on the rod, *R*, helps to open the circuit and to keep it so. The weight also affords a means of varying the point at which the circuit-breaker operates. The magnetizing coils and the distance between the core, *C*, and strip, *I*, can be varied, of course, and the opening of the contacts thus adjusted for different current values. A rather long gap between *I* and *C* has been found to be desirable to secure reliability and quickness of operation. This is because the magnetic force which attracts the iron strip, *I*, increases so rapidly as the strip approaches the core that a great acceleration is imparted to the moving parts, and the contact pieces are very rapidly pulled out of the mercury.

Mercury contacts are used because of the freedom from sticking and ease of construction. The mercury is held in auger holes in wooden blocks, and wires, *W W*, making permanent connection with the mercury are carried in over the tops of the blocks, as shown in the sketches. One of these wires goes directly to one binding post of the instrument and the other to one terminal of the magnet winding; the other terminal of the winding is led to the other binding post. The tips of the stationary wires dipping into the mercury are amalgamated by dipping them in nitric acid, after cleaning them with sand paper, and then placing them in mercury for a few seconds. The tips of the wire, *S*, are treated in the same manner. The wire, *S*, is held in place on the iron strip, *I*, by soldering. The screw supports, *E E*, allow sufficient adjustment and at the same time afford a very simple and efficient bearing.

A ½-in. x 2-in. iron bolt forms a very good magnet core, and may be held in place by counter-sinking the head of the bottom side of the base, as shown in the illustration. A nut, *D*, of brass is used to hold the coil in place, and it also serves to prevent the bolt forming the magnet core from dropping out of place. It is best to use non-magnetic material for this nut, as one of iron or steel would tend to distort the effective field and lessen the pull for a given current. The upper end of the magnet core should be machined off, as indicated in the illustration, to about the same curvature as that described by the end of the swinging iron arm, *I*, but mounted eccentric to it so that the strip, *I*, will be nearer the magnet pole when it is opposite the lower end of the arc than it is when opposite the tip of the pole. An inclined flat surface at the upper end of the core may be used instead of the curved one, and the results obtained will be practically the same.

The winding will depend upon the current to be passed, the length of the gap and the balancing of the iron piece, *I*. The coil should be about ⅜ in. deep, radially, and ¾ in. long, parallel with the core. About 500 ampere-turns will be sufficient for breaking the circuit. The following table gives approximate sizes of wires corresponding to different maximum current values:

Wire sizes, B. & S. gauge:—	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Amperes:—	47	37	30	23	19	15	12	9	7	6	5	4	3	2½	1¾

The holes for the mercury must have such dimensions and be so arranged that the span wire will swing clear when the breaker throws. In the illustrations, this point has been overlooked and the span wire, *S*, would strike against the side of the block and thus fail to open the circuit, unless it were suspended from *I* by a stirrup. This method of support is quite good, though it makes it somewhat more troublesome to restore the circuit, which becomes a nuisance when the circuit-breaker is used as a switch as well as a protective device.

A circuit-breaker similar to the one here shown has been in use in the writer's laboratory for about a year, and still operates with accuracy and certainty. It is set to break at 12 amperes, and will break within one-fourth of an ampere of that value when the current is raised gradually to that point. On short-circuiting a 115-volt, direct-current circuit through this circuit-breaker and a Weston ammeter, the needle of the ammeter reached the 20-ampere mark on its scale at the instant when the device operated. For smaller currents, by reducing the mass of metal to be started in motion, the time of opening could be still further reduced.

Various modifications of this form will readily suggest themselves and quite a number have been tried by the writer; but all things considered, especially simplicity and quickness of operation, this type strongly recommends itself. The cost of such a piece of apparatus is largely the cost of labor, as the total cost of materials will not amount to more than half a dollar. As great accuracy in construction is not required, it is not necessary to be a skilled machinist in order to make it.

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Safety Valve Rules.—Nearly all the engineering handbooks give different safety valve rules. A very simple set of rules is given by Mr. Thomas Hawley, formerly chief of the boiler inspection department of Massachusetts, as follows:

"To find effective weight of lever, multiply weight of lever by distance from its center of gravity to fulcrum, and divide by distance from center of stem to fulcrum.

"To find effective weight of ball, divide weight of ball by distance from fulcrum stem and multiply quotient by distance from center of stem of fulcrum.

"To find length of lever, add together the effective weight of lever and weight of valve and stem and subtract this sum from total steam pressure on valve seat at blowing-off point. Divide the remainder by weight of ball and multiply quotient by distance from stem to fulcrum.

"To find blowing-off pressure, add together the effective weight of lever and weight of valve and stem and effective weight of ball. Divide this weight by area of value."—***Exchange.***

OILING SYSTEM FOR POWER PLANTS.

BY P. E. MOOCK.

A good oiling system that can be depended upon at all times, and is, in fact, more reliable than the ordinary oil cups and filters, is a valuable addition to any power plant. The first thing to be considered in connection with a good oiling system are drainage pipes and tank. All oil should be trapped in the neatest manner possible, which means that this must be done as close as possible to the point where the oil leaves the bearing. The writer has found that for side-crank engines on which a circular shield is used, a complete housing between the shield and the cross-head, covering the connecting-rod, is a great saver of oil. It looks odd at first, but when used with engines that are completely housed up the appearance is improved somewhat.

It is absolutely necessary to make tight joints at all places where oil is led off from an engine bed, as any amount of oil, however small, that leaks by and has to be wiped up makes a mess and is, of course, wasted. This remark also applies especially to the joints of the shields on both sides of the main bearing, which usually catch the oil from the bearing, crank-pin box and eccentrics. After considerable experience with different methods of packing shield joints, which is usually a difficult task, as they are hard to get at, the writer found the following to be a very good method, as well as an inexpensive one:

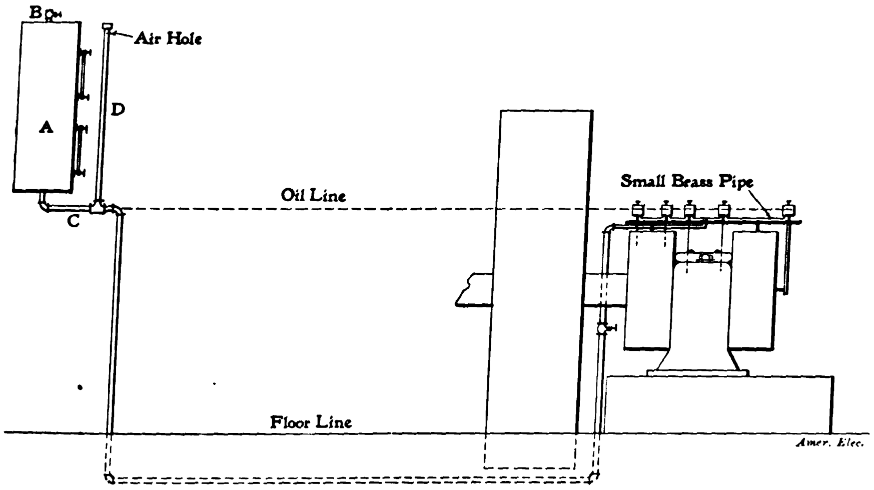

FIG. 1.—OIL SYSTEM HAVING A CONSTANT HEAD.

Wipe off thoroughly all oil and grease, and then at the line where the shield and the bed-plate meet, put on a coat of shellac, using a small brush, or what is just as good, a piece of cloth, tied on the end of a stick, so as to be able to get under and around the crank disc. When this coat is partially set, lay on ordinary friction tape over the joint, and apply several coats of shellac to this. This makes a "seal" which is practically indestructible and will remain until the joint is broken by removing the shield.

The writer has had experience with quite a number of oil delivering systems, both of the gravity and force feed types. Most of them were more or less unsatisfactory; the force feed because of high pressures that are maintained, making it necessary to flood the engine with oil for the reason that if the sight feed is throttled, any small particles of foreign matter, or even the vicosity of the oil itself, will be likely to stop the feeding. The gravity system has some advantages over the forced feed, as the tank can be placed at so moderate an elevation that the sight-feed nozzles can be set nearer full opening, but even in this case the differences in pressure due to the varying heights of the oil in the tank would be considerable, causing oil to drop very much slower when the tank is nearly empty than when full. This will be more readily appreciated when it is remembered that an ordinary oil cup two or three inches high feeds very much faster when it is full than when it is nearly empty.

The secret of a successful oiling system lies in keeping the oil which supplies the sight-feed nozzles under a constant head, regardless of whether the supply tank is full or nearly empty. One method of accomplishing this is illustrated by the accompanying diagram, where *A* is the main supply tank, having upper and lower gauges showing the level of the oil; *C*, a supply pipe running to the engine or engines; *D*, a stand-pipe with a hole in the side near the upper end of the pipe, this end being closed to keep out dirt, and *B*, a valve at the top of the tank for filling purposes; this being preferably attached to a pipe so that oil can be pumped into the tank, this valve being closed air tight when the tank has been filled.

When the tank is first filled, the oil will rise in the stand-pipe, *D*, to the same height as in the tank. The valve at the top of the tank then being closed, the oil in the stand-pipe, *D*, will feed down to a point where a little air will force its way into the bottom of the tank, thereby allowing some oil to run out, and this point will be the constant oil level. In the writer's opinion this should not be more than six inches above the level of the sight-feed oilers.

The sight-feed nozzles should all be on the same level, of course, and when once properly set need never be shut off, since a valve is placed in the main feed pipe to each engine, and it is only necessary when starting or stopping an engine to open or shut this valve. The writer's preference is to leave oil cups on the important bearings, such as the main bearing, crank-pin box and eccentric straps. A common level will be maintained in all the cups at all times, no matter whether the feed is on full or shut off entirely, if the cups are all on the same level. The cups can be connected by bent pieces of ¼-in. tubing, as shown in the sketch, drilling holes in the bottoms of the cups and soldering the ends of the brass tubes in them; thus connecting them in series. The supply pipe delivers at the center of the group and feeds both ways.

At other places, such as outer bearings, cross-heads and guides, sight-feed nozzles may be used. Both will work equally well, conditions being right. The use of cups has the advantage that if from any cause the oil supply from the main tank should be cut off, the cups being nearly full would act as reservoirs, and as they would keep on feeding, the oil level would be lowered, which would be (or should be) noticed by the attendant, and the supply replenished by means of a hand oil can until the trouble could be remedied. While the danger of this happening is very remote, yet it should be provided for, and in the case of sight-feed nozzles being used without cups throughout, a small auxiliary tank could be placed between the shut-off valve and the individual feeders. This need not be left on, it being necessary only to have it fitted up so that it can be quickly applied in an emergency.

The main supply tank should be tapped several inches from the bottom, to keep clear of sediment, and a good screen over the drain and supply pipes should be provided for keeping out foreign matter, as well as helping to purify the oil. The matter of filtration, however, is not of so great importance as some seem to think; if an engine bearing is in proper shape and well taken care of, there is no cleaner, smoother place to be found, and in passing through such a bearing oil will absolutely not be harmed. If there are any metal particles in the oil the way to get it back nearest to its original color is to let it stand in a closed vessel for several weeks. Indeed, this is an ideal way of cleansing oil, and all that is necessary is a small oil house in which can be stored several hundred gallons of oil. The writer recommends in this connection the use of a small filter principally for removing entrained water from the oil, and as the best results are obtained by slow filtration, this part of the system should be arranged so that the oil will pass through the filter regularly drop by drop as it leaves the engine, drawing off the water at the bottom and adding sufficient new oil to maintain a constant level.

The writer has not attempted to give all details; he has endeavored merely to give sufficient data to enable anyone interested to work out the arrangement to their own satisfaction. This system is one that any engineer during leisure hours could install, and it is inexpensive. The cost of an outfit, aside from labor and the oil house, for a 1,000-h.p. plant need not exceed $60.

and in a plant of this size will save its cost in oil in six months.

[The foregoing is a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers.]

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AUTOMATIC TELEPHONE SYSTEMS.

The Ness Interior System.

BY A. DALLAM O'BRIEN.

The Ness automatic intercommunicating telephone system is applicable to all installations of private telephones where a number of instruments are to be connected in an intercommunicating relation, the standard switches having 10, 16, 20 and 24 points. The instruments are adapted, as will be explained later on, to be connected so as to use one central ringing and talking battery, or, they can be installed to use a central ringing battery and individual talking batteries located at each station.

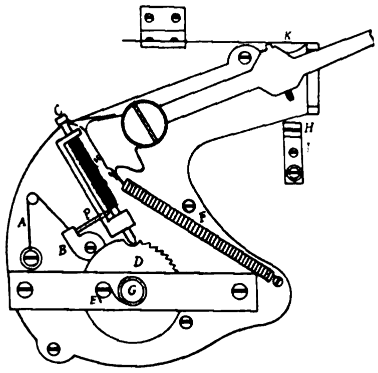

FIG. 1.—AUTOMATIC SWITCH.

The automatic switch is intended not only to enable the user of the telephone to signal and obtain connection with any other station in the system, but also to bring the instrument into its normal connection with the line when the conversation is finished, and to restore the bell connections so that the instrument may be signalled by any other station. This result is obtained by the action of the user in replacing the telephone receiver upon the hook. Inspection of Figs. 1 and 2 will show how this is accomplished. Fig. 1 is a sketch showing the switch mechanism and Fig 2 is a front elevation of a wall-set, showing the switch lever, ringing strip, and contact studs mounted on the face of the box. To call any desired station, the person using the telephone turns the switch lever to the left until the under contact strip, *B*, Fig 3, makes connection with the stud of the station required, then by exerting a downward pressure on the button at the end of the lever, the contact, *A*, is brought in connection with the ringing strip, which is connected to battery. Contacts *A* and *B* being in metallic connection through the spindle of the lever, current is sent out on the line of the station desired, and that station is signalled in a manner described farther along.

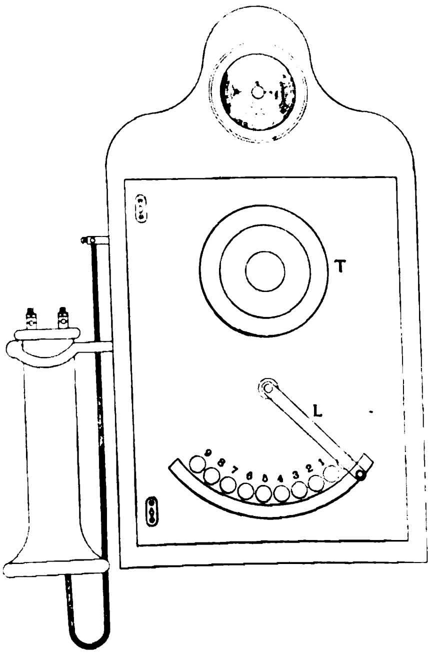

FIG. 2.—ELEVATION OF WALL TELEPHONE.

The telephone being off the hook, and the lever being turned to the contact stud of the desired station, the pin, *C*, Fig. 1, engages with a tooth on the wheel, *D*, and holds the lever in the desired position, during conversation. When the telephone is replaced upon the hook, the projection which is fastened to the end of the hook switch, engages with the head of the pin, *C*, and lifts the pin out of engagement with the tooth of the wheel, *D;* the spring, *E*, which is coiled around the shaft, *G*, then acts to bring the switch lever back to its normal position, as shown in Fig. 2. In order that during the return of the lever to its normal or home position it may not be arrested by a re-engagement of the pin, *C*, and wheel, *D*, a dog, *B*, is provided, which is pressed by a spring, *A*, so as to occupy a position under the pin, *P*, which is carried by the pin, *C*, thus holding it out of engagement with the ratchet wheel until the rotation of the lever is completed. At this point a cam on the under side of the ratchet wheel, pushes the dog, *B*, out of engagement with the pin, *P*, and allows *C* to drop into position against the wheel; in this way normal conditions are restored.

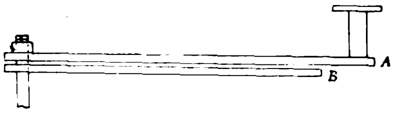

FIG. 3.—CONTACT STRIP.

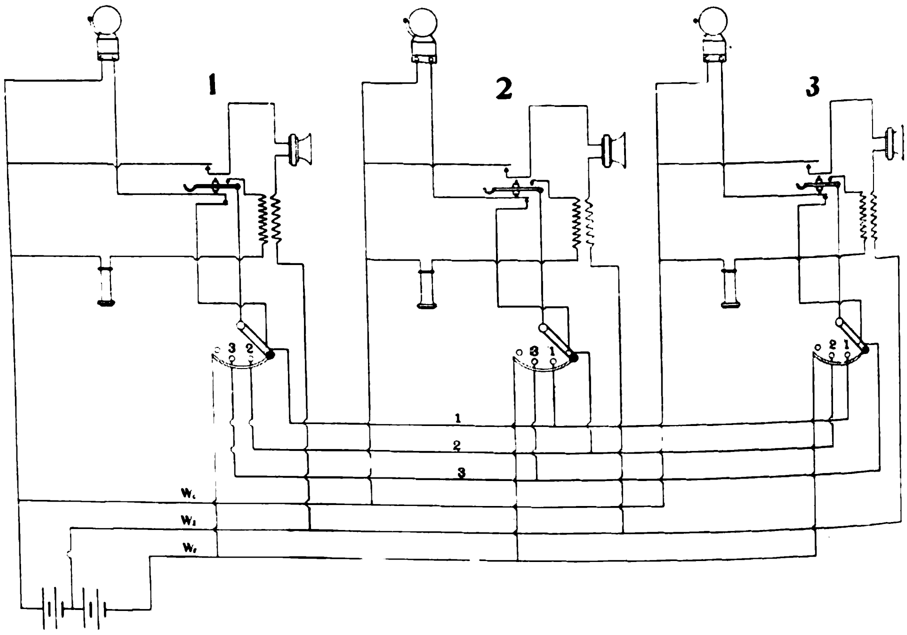

FIG. 4.—WIRING DIAGRAM FOR THREE INSTRUMENTS WITH CENTRALIZED RINGING AND TALKING BATTERY.

Fig. 4 is a wiring diagram for three instruments connected with a centralized ringing and talking battery. The batteries are preferably located at some central point of the system, from 4 to 6 volts being required for the transmitters, according to the distance of the phones from the battery, and about 8 volts being required for the ringing current. One set of cells is used for both purposes, the current lead for the transmitters being tapped to some intermediate point in the batteries, as shown in the diagram. Where it is possible to do so it would probably be best to run a cable containing the necessary number of wires throughout the system tapping that cable at each station.

As shown in Fig. 4, one wire is run from each station to every other station in the system, and in addition, a transmitter battery lead, *Wt*, a ringing battery lead, *Wr*, and a common return wire, *Wc*, the latter acting at once as a return for the transmitter, talking and ringing circuits. Each instrument is equipped with a low resistance vibrating bell and an induction coil, the primary winding of the coil having a resistance of ½ ohm and the secondary winding 50 ohms. Suppose that Station 1 wishes to call Station 3; the switch lever at Station 1 is moved to contact 3 and the lever depressed, when current flows from the battery to the ringing strip, thence through the lever and contact 3, wire 3, and the home contact at Station 3, through the lower hook switch contacts (which, as the receiver is on the hook, are connected) through the bell, and back through the common return to the battery, thus signalling the station.

When the signal is answered at Station 3, by the removal of the telephone from the hook, the two upper contacts of the hook switch are brought into connection, and at the same time connection is established through the third upper contact on the hook switch with the secondary of the induction coil, and thence through the switch lever home contact and wire, 3, to the contact stud at Station 1; here the connection is continued through the switch lever, the hook switch contact, secondary winding, telephone receiver, the common return wire, *Wc*, and the receiver at Station 3, thus putting the receivers and the induction coil secondaries at the two stations in series with each other on the line.

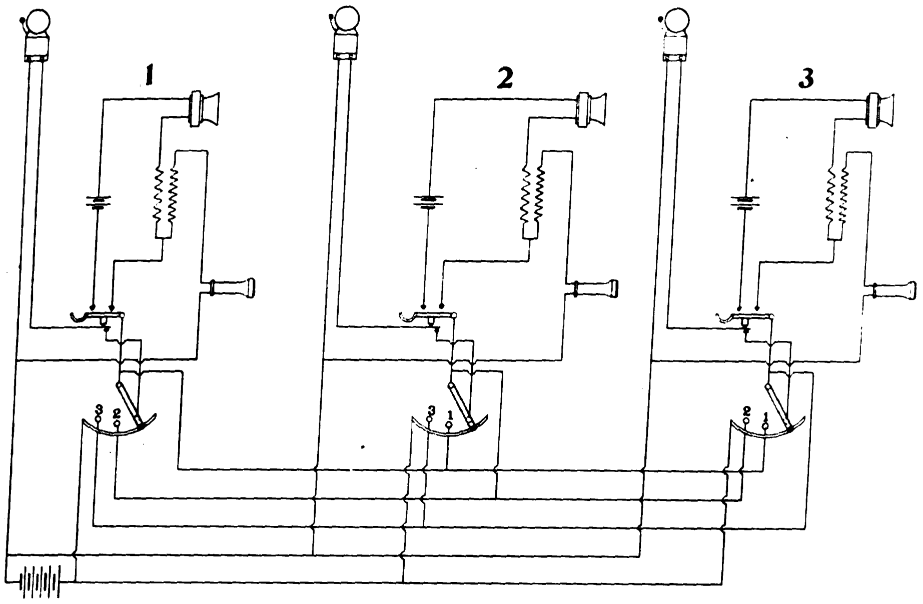

FIG. 5.—METHOD OF WIRING WITH LOCAL TALKING BATTERY AT EACH STATION.

The connection of the two upper hook switch contacts closes the transmitter circuit and current flows from the battery through the primary of the induction coil, through the transmitter and thence through the common return wire back to battery. Conversation is carried on through the medium of the induction coils, as is the case in the ordinary magneto system.

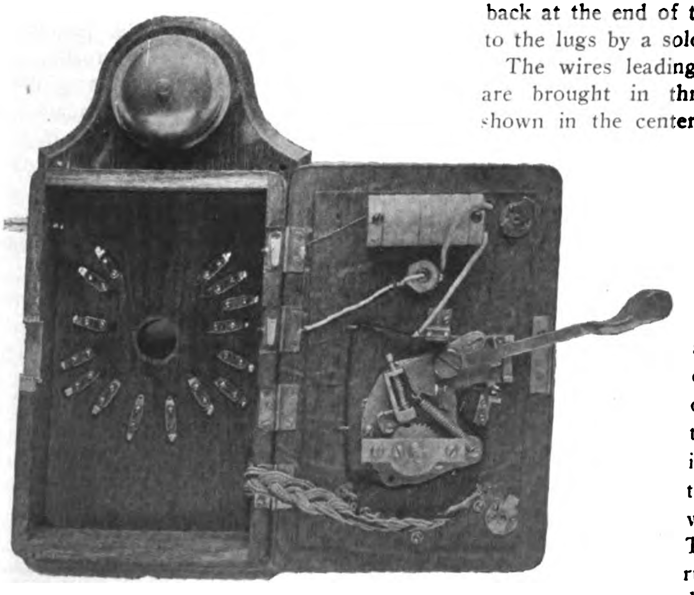

FIG. 6.—INTERIOR VIEW OF WALL TELEPHONE SET.

Fig. 5 shows the method of wiring when using local talking batteries at each station. In this case, the hook switch is arranged to close the transmitter circuit and also to connect the induction coil secondary and the receiver into the line when the telephone is removed from the hook. The operation of signalling is the same as in the previous case. The local transmitter batteries have an e.m.f of about 4 volts, and the induction coils are the same as are used with the centralized talking battery.

Fig. 6 is a photograph of the wall telephone set with the cover thrown back, showing the interior of the box and the mounting of the switch and induction coil. The box is provided with a false back, on which are mounted lugs, as shown in the photograph. The contact studs shown in Fig. 2 project through the cover of the box, and to them are soldered wires made up in a flexible cable, which is carried through the interior of the box and brought up behind the false back. The wires are then pulled through holes drilled in the back at the end of the lugs, and made fast to the lugs by a soldered connection.

The wires leading to the other stations are brought in through the large hole shown in the center of the box, and are soldered to the free ends of the lugs, thus completing the connection between the contact studs at the various stations. Where single wires are run between the different stations, it is only necessary to tap them at some convenient point and run the tap to the instrument, where cable is used. The best plan is to run the main cable through a small junction box at or near each station, and run a short cable from the junction box to the instrument.

The battery wires for the transmitter and for ringing purposes are brought in in the same manner, and lugs are provided on the false back, to which they are connected. From these lugs the wiring is carried to the transmitter bell and hook switch contacts. Fig. 6 shows the arrangement of the local wiring in the interior of the box and the use of the hinges on the cover in completing the circuits.

Fig. 7 illustrates a desk instrument with the bottom removed, showing the method of mounting the automatic switch and the contact studs. With the desk instrument it is necessary to use a small junction box wherein the wires or cable from the other stations terminate, and from this point a flexible cable carries the wires to the base of the instrument, where they are soldered to the contact studs in the usual way.

The arrangement of circuits shown in the diagrams allows intercommunication between all the stations in the system, and admits of all the stations being in use at the same time; thus in a system comprising ten stations, five separate conversations may be carried on at once. With the centralized ringing and talking battery method of installing the system, however, when the lines are of considerable length some difficulty may be experienced from cross talk. An inspection of Fig. 4 will show that the transmitter battery lead and the common return wire act in practically the same way as the bus-bars on a switch-board. Where these leads are of considerable length they will naturally have an appreciable resistance, and in consequence the fluctuation in the resistance of a transmitter at one of the stations, and the resulting change in the value of the current flowing through the circuit, will cause a change of potential to take place on the battery lead, and this change will cause changes in the current flowing through such other transmitters as may be in use, and repeat through the medium of the induction coils, with more or less distinctness, the words being spoken into the transmitter considered. It can readily be seen that should a number of conversations be taking place at the same time, and should the battery lead be of considerable length, the resulting cross talk might become intolerable.

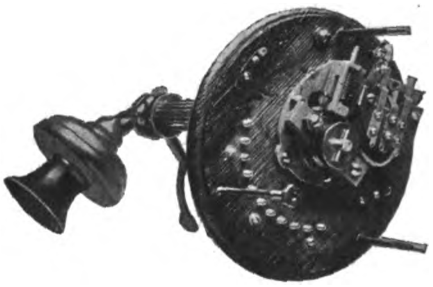

FIG. 7.—DESK TELEPHONE SHOWING SWITCH.

In installing this centralized talking battery system in private houses, the question of cross talk would not prove a serious one, as it would in the case of a business house where the telephones are liable to be in constant use. The use of local transmitter batteries at each station, as shown in Fig. 5, will very greatly reduce the cross talk. In all common return systems, however, there is some liability to interference between the various circuits, as when two stations are connected together and the telephone is removed from the hook at a third station and a connection secured, the receivers at the two previously connected stations form a parallel circuit with a portion of the common return wire, and there is a possibility of there being sufficient current in the receiver branch to affect them. Under ordinary circumstances, however, the impedance of the receiver circuit is so much greater than the resistance of the common return wire than the current flowing does not cause an appreciable effect. In order to avoid all possibility of cross talk, the instruments can be wired with a complete metallic circuit from each station, the wires being composed of twisted pairs.

The instruments are also furnished equipped with a magneto generator and a polarized bell for signalling. The right-hand contact stud on each instrument is left blank, and this is used as the "home" point, the numbering beginning with the second stud. The Holtzer-Cabot Electric Company, of Boston, manufactures these instruments.

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FAILURE OF DIRECT-CURRENT DYNAMOS TO GENERATE.

BY E. C. PARHAM.

Most of us who have had to do with operating dynamos, know that there are times when the machines refuse to do their duty. A dynamo never shirks its duty through pure "cussedness"; its failure can be generally traced to some disorder. A most common trouble is failure to "pick up," due to the field magnet having lost its residual magnetism.

In the factories where the dynamos are made, the completely assembled dynamo is, of course, where practicable, given a running test under-load and over-load before it is shipped. It is very seldom that the tester has any serious trouble in getting the dynamo to generate, although it may never have had any current passing through any part of its winding to give it initial magnetism. The field frame or magnet poles usually have sufficient residual magnetism to enable the dynamo to pick up its field when the other conditions of running are proper for doing so.

If one takes a rod of iron and lays it so that it points north and south, tapping it with a hammer while in this position will cause the piece of steel after awhile to become a magnet—not a very strong magnet, but still a magnet. When a dynamo is in course of construction in a machine shop, some of its steel or iron parts necessarily at times lie north and south; the earth's magnetic force affects these parts and tends to magnetize them, but the metal is supposed to have more or less magnetic friction, and its molecules resist to a certain degree the effort of the earth's lines of force to twist them into the magnetized position. The earth's magnetic field is so weak that it cannot magnetize the iron or steel without some assistance. Now filing and hammering the steel parts of the dynamo cause the molecules to vibrate more or less, and thereby give them more freedom of motion to turn; the magnetic force of the earth can then twist them around more easily. As a matter of fact, with the assistance of the hammering and filing, the earth's field magnetizes the particles to such an extent that they remain so unless stronger lines of force be made to act upon them in the opposite direction.

The usual result of this is that the dynamo field frame leaves the machine shop with magnetism enough to enable the dynamo to pick up its field. Strictly speaking, the slight amount of magnetism acquired in the machine shop would not be regarded as residual magnetism, for the reason that residual magnetism is generally construed to mean the magnetism that remains in the field frame and pole pieces after a magnetizing current has been applied and removed; however, no great amount of harm will be done by considering any magnetism that resides in the dynamo as residual magnetism, to whatsoever cause it may be due.

Sometimes a dynamo may be so large or its construction such that it is shipped in parts without a running test at the factory, to be assembled at its destination and tested there. Under such conditions, it is often found that the dynamo has lost what residual magnetism it may have had when it left the factory. The same kind of vibration that can help to give the steel parts magnetism can also help these parts to lose their magnetism, the vibration in this case having been caused by the jolting on the train. Again, dynamos in regular operation from day to day sometimes lose their residual magnetism. The engineer shuts down at night with everything apparently all right; next morning when he goes to start up, he finds that the machine will not pick up its field. When there are other machines running in a station, loss of residual magnetism is not such a serious thing, because a current from one of the other machines can be passed through the field coils of the "dead" machine and its residual magnetism restored. Dynamos that operate on the same service can't very well lose their residual magnetism, because the field windings of all are, as a rule, connected across the bus-bars in common, and so long as any machine is in operation there will be a source of field excitation for all of the others.

If, however, there are two machines on the same service, and both of them have their field windings connected on the machine side of the circuit-breakers and the main switches, when starting up either dynamo, it must pick up its own field; if it refuses to pick up and the trouble is found to be due to loss of residual magnetism, its field must be excited from the other dynamo. To do this, put the good dynamo into service, so as to make the bus-bars "alive"; next lift the brushes or disconnect one of the armature terminals of the dead machine, and while the circuit through the machine's armature is thus opened, close its circuit-breaker and switches just as if it were going into service; current from the bus-bars will then excite the field of the machine. Upon opening the switches and restoring the brushes or disconnected armature terminal to place, the dynamo will readily pick up its field under the usual conditions if it is loss of residual magnetism that it has been suffering from. Special care must be taken to make sure the armature circuit of the affected machine is opened before closing its switch and circuit-breaker for magnetizing it, and that either the main switch or the circuit-breaker is again opened before the armature terminal or brushes are restored to place after charging; failure to observe these precautions, will result in a short-circuit.

When the power station contains but one constant-potential dynamo (such as a street railway generator or an incandescent lighting dynamo) and one constant-current dynamo (such as an arc light machine) either of these, in case it loses its field can be re-charged from the other. The arc light machine may be re-charged from the constant-potential machine by putting the field windings of the two machines in series with each other, disconnecting the winding of the arc light machine from its armature circuit. The constant-potential dynamo field can be re-charged from the arc light dynamo by connecting its series field winding, if it has one, in series with the regular working circuit of the arc machine, just as one of its lamps is connected. If the dynamo to be charged has no series winding, disconnect the arc dynamo from its lamp circuit and connect it by means of temporary wires to the shunt field of the dynamo to be charged; then start up the arc dynamo with this field winding as its load instead of its lamps. If any trouble is had in making the arc dynamo hold its field through the high resistance of the field that is to be charged, connect the coils of the winding in multiple instead of in series. In no case need the current be maintained over a second for exciting a dead field. If, after charging the field, the dynamo is found to have the wrong polarity, simply reverse the connections of the charging lines and charge the field again.

The most troublesome case of lost magnetism is where there is but a single dynamo in the station. When such a station is remote from all sources of current, a battery of storage or primary cells should be kept on hand just for field-charging purposes. In case there is absolutely no available means for re-charging an isolated dynamo the following method may succeed in restoring the field: If the dynamo is a compound-wound machine, set its circuit-breaker for about one-quarter load, short-circuit the machine beyond the circuit-breaker and start the engine. If the dynamo is a simple shunt-wound machine, connect the individual field coils in multiple with each other instead of in series, start the engine, loosen up the brush-holder rigging and rock the brushes back and forth over the commutator. As soon as the slightest sparking is observed at the brushes, in either case, indicating that the machine has found its field, shut down the engine immediately, re-connect the fields as they should be and start up again. The dynamo should now generate all right. As a final resort, in conjunction with either of the above proceedings, increase the speed of the dynamo armature. This can be done by changing the ratio of the driver and driven pulleys or by increasing the speed of the engine, but the engine regulation should not be tampered with by anyone who does not understand exactly what he is doing.

The best way to ascertain whether or not a dynamo has lost its residual magnetism is by means of a voltmeter. Provide the voltmeter with two test lines having sharp, clean copper points on their ends. If the dynamo field terminals are connected outside of the circuit-breaker, trip the breaker; if the field terminals are connected inside of the circuit-breaker, open the field switch or disconnect one of the field leads; then bring the armature up to normal speed and hold the voltmeter test lines across the brush-holders, if the brushes are carbon, but on the commutator itself on the "leaving" side of the brush-holders, if the brushes are copper and seem to be at all burned. If the dynamo is all right as far as residual magnetism is concerned, the voltmeter should indicate from five to twelve per cent of the dynamo's normal voltage; if the voltmeter indicates little or no e.m.f., the residual magnetism is gone and must be restored. Should the voltmeter indicate an appreciable voltage, it would be natural to conclude that the failure to generate must be due to some other cause than loss of residual magnetism.

Lessons in Practical Electricity

THE INCANDESCENT LAMP.

As previously stated, the resistance of an incandescent lamp filament is much lower when hot than when cold. In practice, the difference is approximately 1 to 2; that is, the resistance cold is about twice the resistance when burning at normal candle-power. Consequently, incandescent lamps cannot be used for dead resistances when the results are based on the actual resistance of a lamp or bank of lamps, within close limits.

The illuminating power of a lamp is rated in so-called candle-powers, and the power consumption is stated in watts per candle-power, measured when the lamp is giving its rated candle-power, but this condition is not obtained with any incandescent lamp through a large portion of its active life. When a new lamp is put into circuit, it usually gives the full rated candle-power, or a trifle more, at the start, and the candle-power soon rises to a value from 6% to 10% higher than the rated value and then begins to fall off, the diminution being continuous up to the end of the filament's life. This is illustrated in Fig. 1, in which the relation between candle-power and life is indicated by the curve, or more accurately, the series of straight lines, crossing the chart diagonally. In the case plotted here, the candle-power started at 16.2 and rose to 17.3 within the first 50 hours, then fell gradually to 17.2 candle-power at 100 hours, 16.8 candle-power at 200 hours, and so on down to 14½ at 600 hours. It should be remarked just here that the rate of decrease does not change abruptly at points along the length of the curve, as the diagram might be construed to indicate; the angles in the curve are due to the fact that the tests for candle-power were made at these points, and straight lines drawn from point to point, the object being merely to indicate in a general way the character of the actual curve. In the present case, the actual curve if it could have been plotted at very short intervals and with absolute accuracy, would have been something like the dotted line in the diagram.

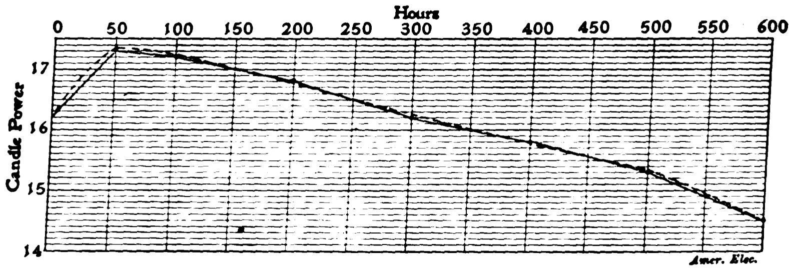


FIG. I.—CURVE OF CANDLE-POWER AND LIFE.

The rise and fall of candle-power are due to changes in the structure of the filament. At first the resistance of the filament decreases, allowing more current to flow, and consequently producing more light. This is indicated by the rise of the curve from 16.2 c.p. to 17.3 c.p. during the first 50 hours of the test plotted in Fig. 1. Then the diminution of resistance ceases, and is followed by the gradual wasting away of the filament, mentioned in the preceding Lesson, which causes a gradual increase in its resistance by reducing its cross-section. The current passing through the filament becomes smaller and smaller as the resistance increases (the e.m.f. at the terminals being constant), and this, together with the decreased surface of the filament and the deposit of carbon particles on the inner wall of the bulb, causes the gradual fall in candle-power indicated by the curve in Fig. 1. The decrease in candle-power is more rapid than the decrease in current, however, so that the cost of producing a candle-power of light after the filament has begun to deteriorate is considerably greater than during the first 100 hours or so. The relation between current and emitted candle-power at different stages of the lamp life differs widely with different lamps, so that no average can be given which would be of any value.

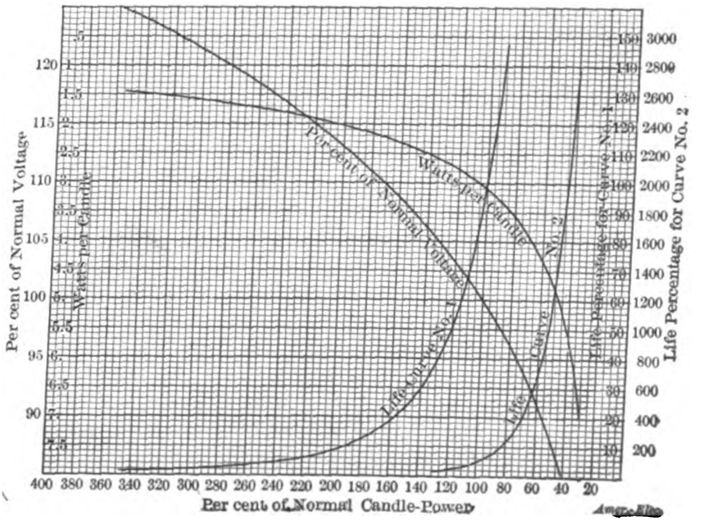


FIG. 2.—CHART SHOWING RELATION BETWEEN VOLTAGE, EFFICIENCY, CANDLE-POWER AND LIFE.

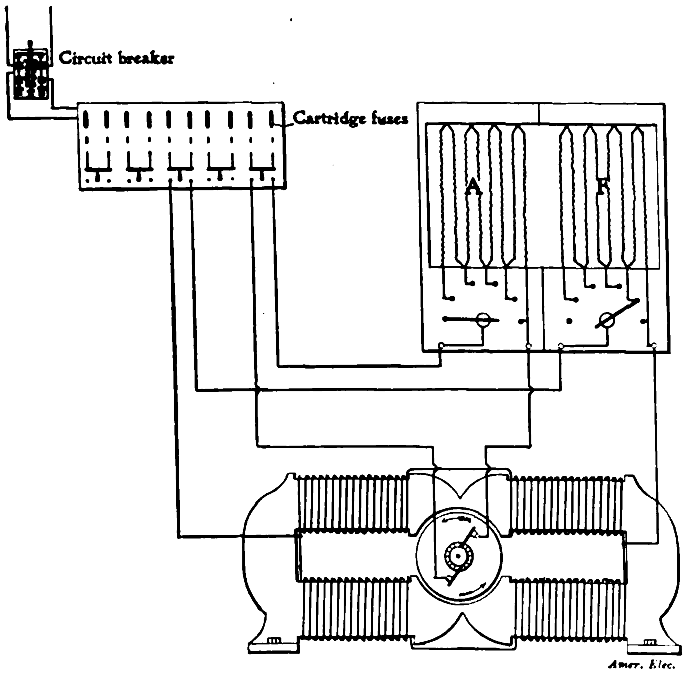
The initial candle-power of a filament depends on the current passed through it, and this, in turn, depends on the resistance of the filament and the voltage applied to it. The table printed last month gave the relations between voltage and candle-power, voltage and economy, and voltage and life, for a short range. The various relations for a 3.1-watt lamp are given more clearly, however, by Fig. 2. From this chart one may ascertain (1) the relative candle-power of a lamp at different voltages, different wattages, or different life lengths; (2) the relative life of a lamp at different voltages, or different candle-powers, or different wattages per candle; (3) the watts per candle at different voltages, different candle-powers, or different life lengths. Thus, if a lamp taking 3.1 watts at 110 volts and giving 16 candle-power be subjected to 116½ volts (5% excess), the candle-power will be about 30% above normal, or 20.8 candle-power, as shown by the curve marked "Per cent of Normal Voltage," the corresponding left-hand scale and the candle-power percentage scale at the bottom of the chart. Tracing back upward from 130 Per Cent of Normal Candle-Power to the "Watts per Candle" curve, and thence to the corresponding left-hand scale, one finds that the consumption will be only 2.6 watts per candle, as compared with the normal rating of 3.1 watts per candle. But the life will be shortened. Tracing back again from 2.6 watts to the watt curve, thence downward to the first life curve, and thence horizontally to the life scale at the right-hand margin, it is found that under these conditions the probable life will be only 38% of the life at 3.1 watts per candle and 16 candle-power. By means of the chart it is feasible thus to ascertain all of the essential results of changing the voltage at the terminals of the lamp, or to determine to what extent the voltage would have to be changed in order to produce certain results. The chart is taken from a very able paper read before the National Electric Light Association in 1901, by Mr. Francis W. Willcox.

Letters on Practical Subjects

Motor Speed Regulation.

To the Editor, American Electrician:—

The accompanying diagram of motor connections illustrates an arrangement which I have used with extremely satisfactory results, and is submitted with the hope that it may be of interest to readers of the American Electrician. As the diagram shows clearly, there are two rheostats, *A* and *F*, the rheostat *A* consisting of wires heavy enough to take the full armature current without overheating, and the rheostat *F* containing wires large enough to carry double the normal shunt field current without overheating. Instead of connecting the field winding in series, it is connected in two parallel groups, so that when the field rheostat, *F*, is all cut out the excitation is double that which the winding would give connected up in the ordinary way. This gives a range of speeds below the normal rated speed of the motor without cutting in any of the armature resistance.



INDIVIDUAL MOTOR CONTROL.

I am aware, of course, that it is common practice to obtain speed control by means of rheostats in the armature and field circuits; this arrangement is not submitted as being fundamentally novel, but as suggesting an easy way to apply this method to an ordinary motor built for single speed operation.

G. A. Sylvain.

Pointe Gatineau, Quebec.

Belt Operation on Pulleys Out of Line.

To the Editor, American Electrician:—

Referring to the note on "Belt Running," which appeared in the March number of the American Electrician, I should like to point out that there is no such simple general rule governing belt action as your note would indicate. It was impressed on my mind repeatedly and most unpleasantly some years ago that a short, wide, double belt, used to drive a 650-light Westinghouse alternator, would invariably crawl over to the low side of the pulley, although the pulley was heavily crowned. This result was mainly due to the fact that power was transmitted from a very large to a very small pulley, so that the arc of contact on the driven pulley did not exceed 130 degrees. This necessitated extra tension on the belt and drew it up as flat as a board, and the percentage of slip was sufficiently large to overcome any tendency of the belt to center itself with the crown; moreover, the breadth and stiffness of the belt rendered it unaffected by the law you enunciate. Lest this may be considered too exceptional a case to quote in opposition to your statement, I hasten to add that so far as flat-faced pulleys are concerned it has not been my experience that in the majority of cases the belt will crawl to the high side of the pulley. A light, pliable and narrow horizontal belt not overloaded would certainly do so, but a new heavy belt of considerable width, or a very tight perpendicular belt, would not. In short, the law while obvious is ordinarily feeble and depends for its effect on a certain degree of continuous contact with the face of the pulley and a certain amount of flexibility in the belt which will allow it to be distorted sufficiently to travel up or over the face of the pulley as a nut travels along the thread of a bolt.

Brooklyn, N. Y. Elmer E. Warner.

To the Editor, American Electrician:—

In your March number, on page 121, the short item concerning belt running is erroneous. There is quite a difference between the condition of a belt running over a pulley slightly conical and that of a belt running on a pulley which has a high side due to the shafts being out of parallel. In the former case, the belt runs to the high side because the action is the same as if the belt were laid on the floor and the pulley rolled over it; in such a case, the pulley would obviously roll so as to describe the arc of a very large circle, and eventually roll off the belt. The two actions are reversible, of course. The latter case is like pushing a plank along on a roller. If the plank is skewed it will run off. "Some men," to whom the note refers, are correct.

Torrington, Conn. John B. Mayo.

[The foregoing letters were unfortunately received too late for publication in the April number, in which another letter on this subject was printed together with an editorial note explaining the origin of the item in question and covering our views on the subject.—Editor.]

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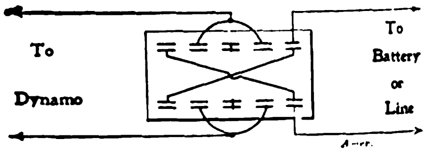
Pole Changing Switch Connections.

To the Editor, American Electrician:—

Thinking that some of your readers might be interested to know of a convenient arrangement for changing the polarity of connections between two circuits, I submit the accompanying diagram, which is practically self-explanatory. With the double-throw switch thrown to one side, the connections between the battery and dynamo circuits are straight, and with the switch thrown to the other side they are reversed. This arrangement is frequently convenient for application to small dynamos which are given to reversal of field magnetism, especially in connection with storage batteries charged from such dynamos. In such a case, it is obvious that it will only be necessary to test the polarity of the dynamo with a polarized voltmeter or similar instrument and throw the switch to whichever side it may be necessary to establish proper circuit connections. In such a case, the switch could just as well be used as the main switch of the dynamo in order to avoid multiplicity of switches. This arrangement is also a good one to apply to the ignition circuit of a gas engine for the purpose of reversing the direction of the igniting current frequently, and thus increasing the life of the igniter points.



POLE-CHANGING SWITCH CONNECTIONS.

Brookline, Mass. E. S. Lincoln.

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A Question of Switches.

To the Editor, American Electrician:—

I have a problem that I should like to have considered by the readers of the American Electrician, namely: Is it practicable to connect incandescent lamps on four floors of a residence so that upon entering on the ground floor the lamps in the hall on the floor and on the second floor may be lighted by pressing a push-button; and when the second floor is reached, the lamps on the first floor may be extinguished and those on the third floor lighted by pressing a push-button, and so on up to the top of the house, except that on the last floor the push-button there will extinguish the lights on that floor and those on the floor below? The push-button switches and connections must be such that when one person has entered the house and gone through this cycle of operations, the cycle can be repeated by anyone going in afterwards, or can be reversed by starting from the top of the house and going downward. Can this be accomplished by using a single switch on each floor?

Stratford, Conn. G. H. MERRICK.

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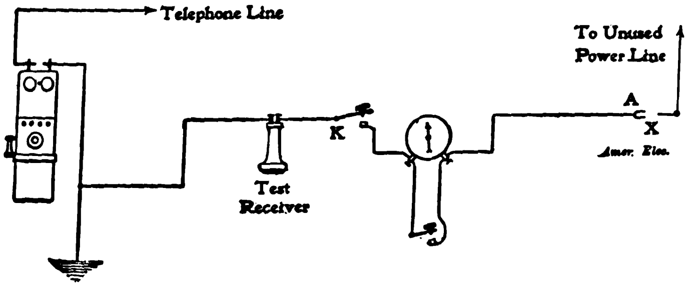
Electrical Disturbances During Thunder Storms.

To the Editor, American Electrician:—

While studying the collection of electric charges on an overhead power line that was out of use at the time, I noted the following peculiar occurrences. The instruments used and their connections with the power line were as shown in the accompanying diagram. While a rain storm was coming up from the south, the galvanometer showed violent deflections when the key, *K*, was closed, and a loud clicking was heard in the test telephone receiver, similar to that of a telegraph instrument when an operator is "dotting" very rapidly. Anticipating injury to the instruments, I disconnected them from the power circuit at the point *X*, and immediately after doing so, felt a slight prickling sensation when touching the end of the wire, *A*. After this wire was disconnected from the power circuit, the same clicking was audible in the telephone receiver, but very faintly, and it lasted only a few moments; at this time the end of the wire, *A*, was fully ten feet away from the power circuit. I should like to have some of your readers express opinions as to what caused the clicking after the wire, *A*, was disconnected. Could it have been due to discharges across the lightning arrester of the telephone set to the ground wire, with which the testing instruments were connected?



COLLECTING ELECTRIC CHARGES ON POWER LINE.

Mesa, Ariz. FRANK W. CERNY.

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A Handy Fire Extinguisher.

To the Editor, American Electrician:—

Some time ago I had an experience with a transformer that was struck by lightning, which I will describe, thinking it may be of help to others who may encounter the same trouble. The transformer was a 50-kw. oil-cooled apparatus operating at 10,000 volts with another transformer of the same size on a three-phase circuit. The lightning discharge caused the oil in one of the transformers to catch fire. The writer threw off the cover of the transformer with a broom-handle and threw a quantity of carbonate of soda into the blazing transformer, which instantly extinguished the flames; the amount of soda carbonate was about sufficient to half fill an ordinary battery jar. The full potential was on the transformer, as the switches were covered with smoke from the oil and I could not see them clearly enough to open them safely. I had occasion at another time to use the same sort of fire extinguisher on lightning arresters, and it saved the entire gang of arresters. In fact, I have found carbonate of soda practically invaluable for just such emergencies in this isolated locality, and would not think of being without a supply.

F. P. DE WILDE.

Lundy, Mono County, Calif.

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"L G's." Equalizer Trouble.

To the Editor, American Electrician:—

Replying to the inquiry of "L. G.," on page 204, of the April number, it appears to me that part of his trouble, if his diagram is correct, is with the connections. He is trying to equalize between points of opposite polarity, and the connections shown by the diagram would connect the series field winding of generator No. 1 to the armature of generator No. 2, exciting the series winding in the direction opposite to normal. If the voltage in generator No. 1 should drop slightly, current from No. 2 would flow through the series field of No. 1 and tend to magnetize it, thus further reducing the voltage. This effect would be cumulative until the voltage of generator No. 2 would be reduced to that of No. 1 by reason of its overload. In order properly to equalize the series windings, the equalizer conductor should be connected to brushes of the same polarity on both machines.

Schenectady, N. Y. IRA M. CUSHING.

Electrical Catechism

734. How can a passing cloud affect a line when there is no discharge of lightning?

This is caused by the action known as influence or electrostatic induction, which is most conveniently discussed by the artificial theory of two electric fluids. A body charged with one kind of electricity breaks up the neutral charge in neighboring bodies, attracting the opposite kind and repelling the similar kind. Thus a passing cloud causes a separation of the current in wires or other conductors, so that a positively charged cloud may cause a temporary current and sparks may pass to the ground as the repelled positive charge from the wire escapes to earth, while the negative charge is attracted to the part of the circuit nearest the cloud. When the cloud passes, the negative charge is no longer bound and immediately seeks to unite with its mate into the neutral state, thus causing a second current and perhaps another set of sparks. Such sparks are usually harmless.

735. How is the presence of globular electricity explained?

Suppose that a stratum of very damp air near the earth is charged inductively by a storm cloud above it, and that between these two plates or electrodes there is a thin dielectric of comparatively dry air, more or less perfectly separating the two charged bodies. This is one of nature's condensers. The layer of dried air is of varying thickness, and hence a better insulator at some points than at others. It is easy to conceive that the electric charge generated in this moist air will reach toward the inducing cloud, which in turn will tend to approach, and the two will thus strive to mingle and restore the disturbed equilibrium. At the border of the partial insulator the moisture-laden air will be drawn partially within a drier stratum, and may be surrounded, cut off and separated from the parent source by a change in the shape of the insulating air. The action of surrounding attractions will now expand this enveloped and charged mass, and the natural sequence of this isolated and expanded charge will be its assumption of a spherical form, and the taking on of a rotary motion.

736. Is the air ever free from electricity?

The atmosphere surrounding the earth is seldom if ever entirely free from electricity. The various causes which are supposed to excite electrical conditions, are one or more of them constantly alive. Evaporation, condensation, thermal changes, and other disturbances will produce changes in the electrical conditions, so that there is a more or less intense action, or either the positive or negative condition, and both these characteristics may change at any time with a change in the exciting causes.

737. What facts are generally conceded regarding atmospheric electricity?

When the sky is free from clouds the atmosphere is always positively charged and its potential rises rapidly as the distance from the earth becomes greater. The electrical condition is often changed to the reverse or negative by the approach of dampness in the form of mists, fogs, etc. It is found to be stronger when the elements are at rest than during atmospheric commotion. There are daily periodical variations occurring as follows: The first maximum is found directly after sunrise, the second shortly after sundown. The first minimum occurs just before sunrise, the second during the afternoon at the hottest part of the day. A yearly variation has been assumed with a maximum in winter.

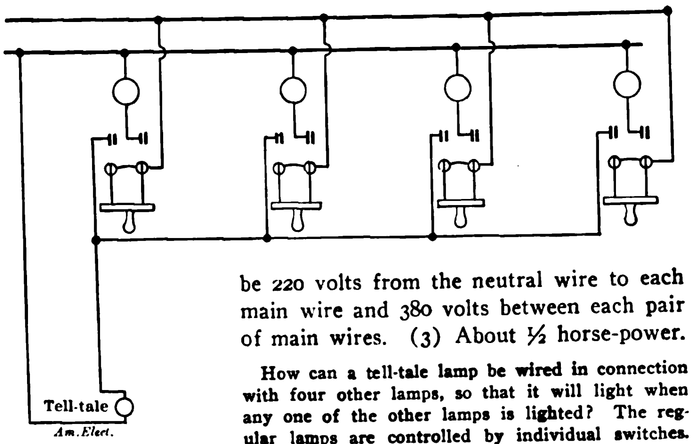
Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

What length of spark is required for the satisfactory operation of an X-ray tube? J. C. D.

Not less than 2½ inches, and preferably 3 inches.

Two commutator segments of a constant potential dynamo heat up so that the solder melts out the ends of the lugs to which the coil terminals are soldered. The winding itself tests free from trouble, but the two segments have arched across from sparking. Which of the two troubles is the cause and which the effect? (2) The armature has 79 coils; can I use a spare commutator with 78 segments, leaving out one of the coils? J. E. S.



The arcing across at the segments short-circuits the armature coil, and the excessive resulting current heats the terminals and causes the solder to melt out. (2) Not without resorting to the clumsy expedient of leaving two of your armature coils disconnected entirely and bridging two of the segments in the commutator so as to leave virtually 77 segments.

Have single-phase 60-cycle alternators ever been made to operate satisfactorily in parallel? E. A. W.

We do not know of an actual case, but there does not appear to be any reason why they should not be thus operated.

What is the best material with which to fill in holes between commutator segments where bits of the mica have been dislodged? J. W. N.

A thick mixture of powdered mica and shellac varnish. This will only serve temporarily, however, and the commutator should be taken down and new mica put in at the earliest opportunity.

The rewound armature of a multipolar dynamo, the original windings of which were destroyed by fire, gives only one-third of its normal voltage. The armature is form-wound with 35 slots and 69 commutator segments. The coils are located in slots 1 and 8 and connected to segments 1 and 12. What is the trouble? C. S.

The armature connection is wrong. If the machine has four poles, the terminals of each coil should be connected to segments 1 and 35. If it has eight poles, the terminals of each coil should be connected to segments 1 and 18, and the coils put in slots 1 and 5. Another difficulty is that your field winding is not strong enough. You can easily ascertain the proper winding by changing the armature and exciting the field until the machine gives the proper voltage.

What e.m.f. would be obtained between any two rings of a group of three connected to equidistant taps in the armature winding of a 220-volt direct-current machine? (2) What is the voltage between any two wires in a three-phase 220-volt system? (3) How much power could be developed by 1-h.p. three-phase motor running on single phase. A. F.

Approximately 135 volts. The actual voltage, however, might vary a good deal from this figure because the ratio between the alternating-current and direct-current e.m.fs is affected considerably by the shape of the pole faces and slightly by the distribution of the armature winding. (2) With three wires, 220 volts. With four wires, the e.m.f. might be 220 volts between each pair of main wires and 127 volts between each main wire and the neutral wire, or it might be 220 volts from the neutral wire to each main wire and 380 volts between each pair of main wires. (3) About ½ horse-power.

How can a tell-tale lamp be wired in connection with four other lamps, so that it will light when any one of the other lamps is lighted? The regular lamps are controlled by individual switches. E. F. H.

Use double-pole switches for the regular lamps and wire them so that they will act as two single-pole switches, one to close the circuit through one of the regular lamps and the other blade closing the circuit through the tell-tale lamp, as shown by the accompanying diagram. You will have to be careful as to the polarity of your connections, or you will be likely to short-circuit the line when two of the lamps are switched in. All of the regular lamps and the tell-tale lamp should be connected permanently to one of the service mains (the same for all lamps).

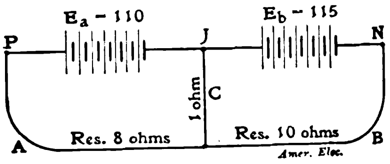
Referring to the description of the electric run-about in the January number, why are four terminals shown on the field-magnet coil? C. W. A.

The coil is intended to have only two terminals. The drawing referred to was made for a motor of the same size with a multiple field winding, and that drawing was used by error to illustrate the winding of this motor. The dimensions of the coil as stated are correct, however.

Why does a Thomson recording wattmeter run faster when the field current is increased, while an ordinary motor runs slower under the same conditions? (2) How are the direct-current commutator terminals tapped off from the alternating primary of a rotary converter? D. M.

Because the load imposed on the armature by the permanent magnet and eddy current disc is relatively great and the armature resistance is so high that the counter e.m.f. is inappreciable, so that the speed is controlled solely by the torque between the field flux and the armature wires. An ordinary motor would run in the same way if its armature winding had a very high resistance and the field were weakened beyond the point where the product of the field flux and armature ampere-turns was sufficient to give the torque required by the load. (2) No such connections are made. The commutator is connected to the armature winding exactly in the same way as in a direct-current dynamo or motor, and the alternating-current collector rings are tapped into the armature winding at equidistant points. If it is a two-phase machine, there are four rings and consequently four taps for each pair of poles. If it is a three-phase machine, there are three rings and three taps for each pair of poles. All of the taps having the same instantaneous polarity are carried to one collector ring.

How is the current flowing in the wires *A B* and *C* in the accompanying diagram computed? The resistances of the wires and the e.m.fs. between the points *P*, *J* and *N* are so marked on the diagram, and the resistances of the batteries or other source of e.m.f. are included in the resistances of the wires *A* and *B* respectively. R. E. H.



Representing the resistance of the wire, *A*, by *Ra*, the resistance of the wire, *C*, by *Rc*, and the resistance of the wire, *B*, by *Rb*, it is evident from Ohm's law that the drop in the wire, *A*, is equal to $Ra \times Ia$ and the drop in the wire, *C*, is equal to *Ic*, as the resistance is 1 ohm. Consequently, the drop between the points, *P* and *J*, is equal to $8\,Ia + Ic$, and is also equal to the e.m.f., *Ea*, of 110 volts. Therefore, $8\,Ia + Ic$ equals 110 and

$$Ia = \frac{110 - Ic}{8} \;\ldots\ldots\ldots\; (a).$$

Applying similar reasoning to the other half of the figure, $Ic + 10\,Ib = 115$, but as the two e.m.fs are in opposite directions, so far as they affect the wire, *C*, one of these voltages must be written negative and the other positive; so in order to fit in with the remainder of the problem the last equation must be changed to read: $Ic + 10\,Ib = -115$, and transposing this the current in the wire, *B*, is given by the equation,

$$Ib = \frac{-115 - Ic}{10} \;\ldots\ldots\ldots\; (b).$$

According to Kirchhoff's law, the sum of all currents meeting at a given point in a system of circuits is zero, and as these currents all meet at the point, *J*, their sum, $Ia + Ib + Ic = 0$, and substituting the fractions representing the values of *Ia* and *Ib* gives the equation,

$$\frac{110 - Ic}{8} + Ic + \frac{-115 - Ic}{10} = 0.$$

In order to clear of fractions, this expression would be multiplied throughout by 40, this being the least common multiple of 8 and 10; this gives $550 - 5\,Ic + 40\,Ic - 460 - 4\,Ic = 0$, which simplifies to $90 + 31\,Ic = 0$, from which it is evident that $31\,Ic = -90$, and therefore, $Ic = -90 = -2.9$. Having the value of *Ic*, the values of *Ia* and *Ib* may be deduced from formulas ***a*** and ***b***.

LAMP HOLDER FOR PHOTOMETERS.

BY J. C. FISH.

It appears evident that most disinterested authorities strongly favor a method of determining the real value of an incandescent lamp as a source of light should be by determining the spherical candle-power of the lamp, and considering it in connection with the actual current required to operate it, in preference to measuring the lamp in the arbitrary manner most generally used at present, namely, for its horizontal intensity.

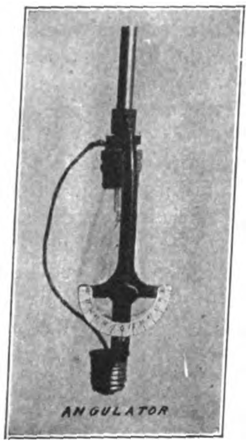


FIG. 1.—SHELBY ANGULATOR.

The principal argument against rating lamps by their spherical candle-power is that there has not been an instrument by which the spherical candle-power measurements can be taken at one reading that is not extremely complicated. To determine the spherical candle-power by taking numerous readings requires considerable time, and is, therefore, conceded to be uncommercial. These facts do not, however, alter the true condition, and the real value of the lamp cannot be determined in any other way.

Prof. C. P. Matthews, of Purdue University, is among the number who have devoted considerable time to the solving of this important question. Mr. Matthews has invented a very satisfactory apparatus for determining the spherical candle-power at a single reading. The expense incurred in the ownership of one of these instruments is such, however, that many feel that they cannot afford to purchase one.

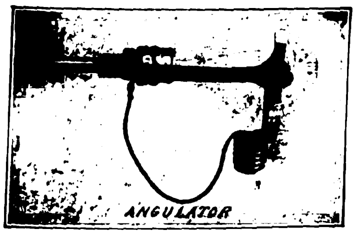


FIG. 2.—SHELBY AUGULATOR.

Professor Sharp, of Cornell University, has also devoted time to the solving of the problem, and has prepared a method of calculating the spherical candle-power of lamps, having various forms of carbons, that is sufficiently close for any commercial purpose. Professor Sharp's method consists of determining the mean horizontal candle-power in the regular manner, and then making one measurement through the tipped end of the lamp, multiplying the mean horizontal by seven-tenths (.7), and the tipped end measurement by three-tenths (.3). The sum of the two results will be very close to the real spherical candle-power of the lamp.

Most owners of photometers have not, until recently, recognized the great advantage of a lamp delivering a large volume of light through the end opposite the base. The attention of the users of lamps was first called to the value of this light by The Shelby Electric Company. This company is now placing on the market an "angulating" device which readily fits into the socket of any standard photometer. By the aid of this device the horizontal candle-power can be determined, and the lamp can then be turned so that the light can be measured at any angle (See Fig. 2).

While the makers of photometers have not encouraged the measurement of lamps in other than the horizontal direction, the various papers read before scientific bodies within the last two years show conclusively that the light delivered through the end opposite the base is in fact the most valuable light the lamp emits. It is a fact, of course, that lamps are invariably used for illumination, and illumination is divided into but two classes, namely, general illumination and local illumination. The value of the lamp for general illumination can only be determined by considering the light emitted in all directions, and that by far the greater part of the light that is used for local illumination is delivered through the end of the lamp opposite the base, or within 45° therefrom.

While the writer considers these statements to be indisputable, the practice of rating the lamp solely by the light delivered horizontally, which light does not enable one to determine the value of the lamp for general illumination, and enters into the value of local illumination only after having been reflected by walls and surfaces, the reflecting qualities of which vary, is continued, and so long as the users of incandescent lamps are satisfied to buy light on the basis of horizontal delivery, manufacturers will, of course, continue to make lamps on this basis.

The angulator, illustrated by Fig. 1, has been designed with a view of placing at the disposal of every one owning or using a photometer a method of determining the value of his lamps regardless of whether the lamp is used for general illumination or for local illumination.

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SMALL PLANT SWITCHBOARDS.

Heretofore switchboards for small isolated plants have been specially designed for the requirements of each case, and inasmuch as no uniformity of construction prevailed, the renewal of parts involved not a little inconvenience. As a solution to this difficulty, the General Electric Company has designed a line of standard switchboards for small isolated lighting plants. The designs include a complete series of combination generator and feeder panels for direct-current isolated plant service. Each panel is a separate and complete switchboard and is not intended for combination with other panels. The boards are uniformly made to provide for a generator and two feeder circuits. Additional feeder switches cannot be added. The material used in the construction of these switchboards is slate, selected with special reference to freedom from metallic or other impurities likely to impair its insulating qualities. The panels are first given a smooth surface and then the various coats of lacquer are applied to give it the dull black finish. The panels are 1½ inches thick, with square corners and beveled front edges. The height of all the panels is three feet, while the width varies from 16 inches to 20 inches, depending upon the capacity. All exposed metal parts on the front of the board, except live copper, are given a dull black finish.

The panels are supported on two 1-in. gas pipes, each 64 inches long, the panel being fastened to the pipe by means of four cast-iron clamps, and the pipes in turn being held in position by two cast-iron flanges fastened to the floor by lag screws. These panels are not furnished with wall brackets, but each panel is equipped with two tie rods which permit the panel to be supported from the wall or from the machine frame, or to stand in the center of the room. The tie rods con-

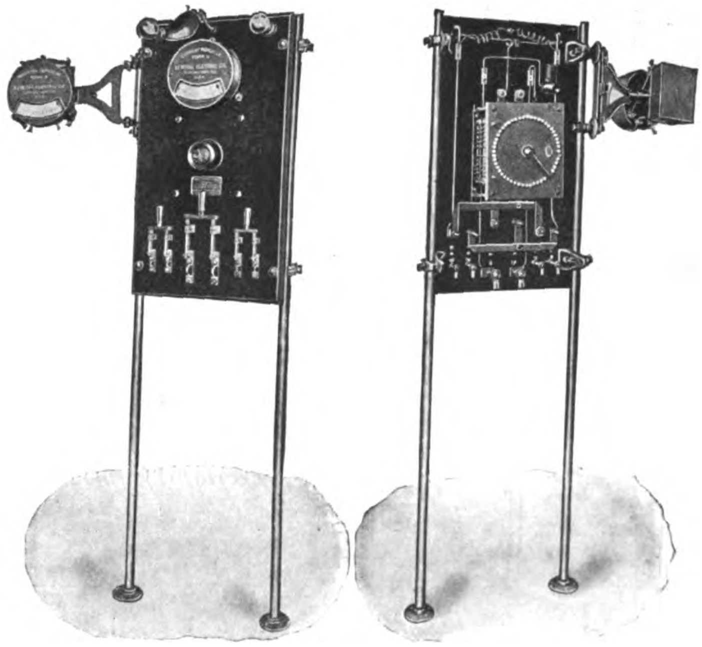


FIG. 1.—FRONT AND REAR VIEWS OF SWITCHBOARD.—FIG. 2.

sist of iron pipes similar to those which support the panel and the necessary clevises, two of which have hinged joints to allow the flanges at the end to be fastened to a vertical, inclined or horizontal surface. Rheostats are not included in the equipment, but the panels are provided with four wrought-iron legs which are so arranged as to support the standard rheostat used with the machine corresponding to the rating of each standard size of switchboard.

Mounted upon these switchboards are General Electric form D lever switches, with three complete sets of fuses for each switch, each feeder fuse having approximately 75 per cent of the capacity of the generator fuse. The ammeter, which is permanently connected in the generator circuit, is the General Electric Company's round pattern form B instrument. Its few parts are strongly constructed, and having no springs, it is particularly free from any element likely to change. While voltmeters are not provided with these panels, since in many installations the illuminating lamp of the wattmeter may serve sufficiently well as a pilot lamp, a potential indicator of the same type as the current indicator, and provided either with a pivoted bracket supported at the top of the panel or with a swinging bracket supported at the side is carried in stock as a standard extra part. A standard two-lamp ground detector is used on these panels; that is, one lamp is connected from each bus to the ground, the voltage of the lamp always being the same as the voltage of the panel. A 16-c.p. lamp supported on a curved lamp bracket and provided with a half round metal shade is included with each panel. The electrical connections of the various parts of the board are shown by Fig. 3. All connections are made with bar copper and terminals are provided for connection to the system. The boards are made only for use on voltages from 125 to 250, direct current, and have capacities from ¾ to 40 kilowatts.

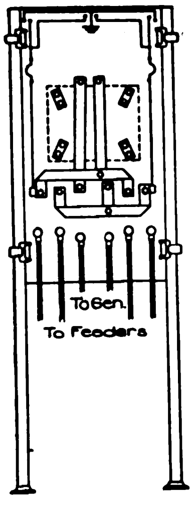


FIG. 3.—BACK OF SWITCHBOARD.

THE CURTIS STEAM TURBINE.

Considerable interest has been manifested of late in the developments made in steam turbines, the performances of two types of which, the Parsons and the De Laval, are already known to readers of this paper. The latest turbine to make its appearance and one which differs in many respects from the turbines mentioned, is the Curtis steam turbine, which is manufactured by the General Electric Company under patents granted to C. G. Curtis. It differs from the Parsons turbine in that the path of the steam is through a segment or portion only of the annular space, while in the Parsons steam is admitted to the vanes through an annular opening; the object being in the Curtis turbine to secure a large wheel diameter for a given peripheral speed.

A second point of difference is that in each stage of the Curtis the steam is expanded to nearly the exhaust pressure of that stage in an expanding nozzle before admission to the moving vanes, so that the steam reaches the moving vanes in the form of a jet traveling at a low pressure, but at a very high velocity. In this way the potential energy of the steam, as represented by pressure, is converted into kinetic energy as represented by velocity, and the movement of the vanes is caused by the impact against them of the steam, whose velocity is thus converted into mechanical power through rotation. Thus far the machine is like the De Laval machine, but by providing two or more stages, each with several series of moving, alternated with stationary lines of vanes, a compounding effect is secured which makes the machine resemble the Parsons in general form of structure much more than the De Laval, which has but one line of vanes.

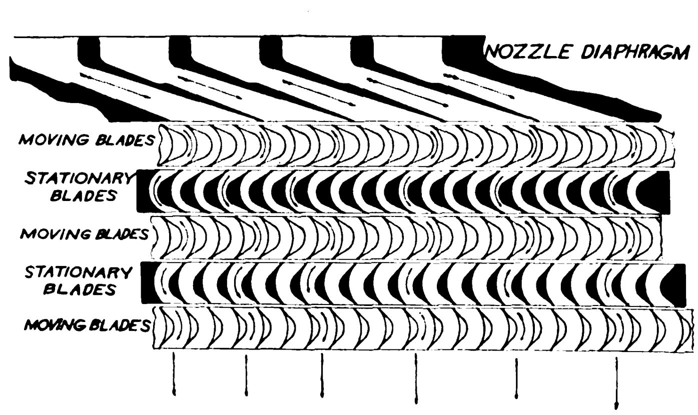


FIG. I.—DIAGRAM OF NOZZLES AND BUCKETS IN CURTIS STEAM TURBINE.

The general arrangement of the turbine nozzles and buckets is shown by Fig. 1 and the functions may be briefly described as follows: Velocity is imparted to the steam in an expanding nozzle so designed as to convert nearly all the expansive force, between the pressure limits used, into velocity in the steam itself. After leaving the nozzle, the steam passes successively through two or more lines of vanes on the moving element, which are placed alternately with reversed vanes on the stationary element. In passing successively through these moving and stationary elements, the velocity acquired in the nozzle is fractionally abstracted, and largely given up to the moving element. Thus the steam is first thrown against the first set of vanes of the moving element, and then rebounds alternately from moving to stationary vanes until it is brought nearly to rest. By this means a high steam velocity is made to efficiently impart motion to a comparatively slowly moving element. The nozzle is generally made up of many sections adjacent to each other, so that the steam passes to the wheels in a broad belt when all nozzle sections are in flow.

This process of expansion in nozzle and subsequent abstraction of velocity by successive impacts with wheel vanes is generally repeated two or more times, the devices for each repetition being generally designated as a stage. There may be various numbers of stages and various numbers of lines of moving vanes in each stage. The number of stages and the number of lines of vanes in a stage are governed by the degree of expansion, the peripheral velocity which is desirable or practicable, and by various conditions of mechanical expediency. Generally speaking, lower peripheral speeds entail more stages, more lines of vanes per stage, or both. The general practice is to so divide up the steam expansion that all stages handle about equal parts of the total power of the steam. The losses and leakages of the earlier stages take the form of more heat or more steam for the later stages, and are thus in part regained. Much water of expansion, which might occasion loss by re-evaporation, is drained out of each stage into that which succeeds it.

The governing is effected by successive closing of nozzles and consequent narrowing of the active steam belt. The illustration shows part of the nozzle open and part closed; the arrows showing space filled by live steam. In the process of governing, the nozzles of the later stages may or may not be opened and closed so as to maintain an adjustment proportional to that of the first stage, which is always the primary source of governing. Some improvement of light load economy may be effected by maintaining a relative adjustment of all nozzles; but in many cases the practical difference in economy is not great, and automatic adjustment of nozzle opening in later stages is dispensed with in the interest of simplicity. In some machines an approximate adjustment is maintained by valves in later stages, which open additional nozzles in response to increase of pressure behind them. These are used as much for limiting the pressures in stage chambers as for maintaining the light load economy.

New Apparatus and Appliances

LONG SCALE ALTERNATING CURRENT AMMETER.

The accompanying illustrations show improved forms of ammeters brought out by the Westinghouse Electric & Manufacturing Company, which are said to possess an uncommon grade of excellence. They are induction instruments, and in principle of operation are closely allied to the integrating wattmeter made by the same company. The scale begins at zero and the divisions are said to be proportioned and uniform above 20 per cent of the full capacity, with a length and openness which permit readings to be made accurately. As an additional aid to easy and correct reading from a distance the dial is made of translucent material, illumined from the rear, while the markings are distinct and the figures large and prominent. The lamps for illuminating this scale are enclosed in a compartment separate from the rest of the mechanism, thereby rendering the working parts immune from heating. In this type of instrument an electromagnet produces a shifting magnetic field in the air-gap of which is an aluminum disc in which currents are induced, resulting in the disc's movement. This motion is opposed by a spring, and the amount of deflection is shown by a pointer mounted on the shaft of the disc. When the pointer is at zero the outline of the disc being spiral, the air-gap closes that portion of the disc having the longest radius. As the deflections increase, the enclosed radii decrease, diminishing the pull on the disc until it becomes directly proportional to the current, the result being a uniform scale of an unusual length for this type of instrument. The claims made for the instruments are that they are unaffected by external fields, are totally dead-beat, and are compensated for changes in temperature and frequency. Friction is said to be a negligible quantity. The instruments are made to certified and legal standards with interchangeable parts and dust-proof cases. This make of ammeter is arranged to operate from 5 ampere secondaries of series transformers, enabling the instrument to be mounted at any convenient point, and rendering it unnecessary to bring the main current to the instrument.

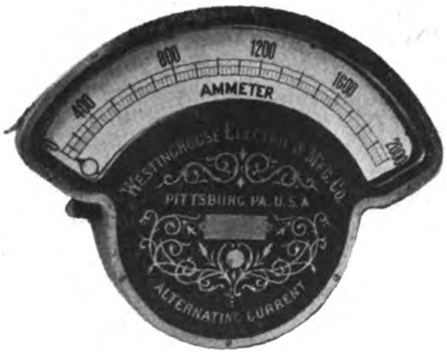


FIG. 1.—ALTERNATING-CURRENT AMMETER.

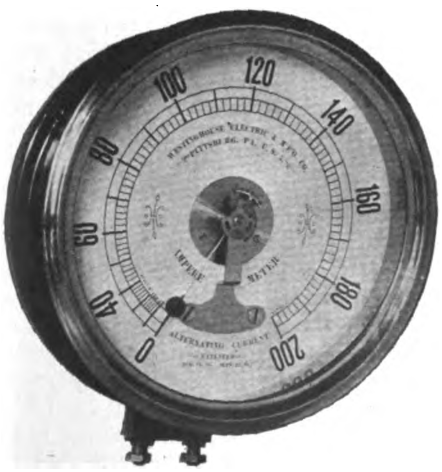


FIG. 2.—ALTERNATING-CURRENT AMMETER.

NEW COMBINATION OHMMETER.

Fig. 3 herewith shows a new form of Sage ohmmeter brought out by Machado & Roller, who are the licensees under the Hanchett and Sage patents. As will be noted, the ohmmeter differs from the older form of instrument, being provided in addition with a galvanometer and an induction coil. Two switches are also provided by means of one of which either the telephone receiver or the galvanometer may be used as the current detector, while with the other either direct current from the batteries or alternating current from the secondary winding of the induction coil may be applied. The galvanometer is of the D'Arsonval type, unaffected by external magnetic influences, well balanced, and of a sensitiveness superior to that of the telephone receiver. The galvanometer is a valuable adjunct since it enables the ohmmeter to be used in places where the noise would make the use of the telphone receiver impossible, and it also gives it the means of working from a false zero in making the Murray test. The induction coil renders it possible to compare capacities and inductances, and to measure the resistance of electrolytes, or the internal resistance of batteries. It is also valuable in locating faults on the lines where an e.m.f. exists at the fault, as for instance, in a submarine cable where one or more conductors are grounded or are both open and grounded. By keeping the telephone receiver circuit closed, the e.m.f. causes a continuous current to flow which does not affect the telephone receiver, the alternating current from the induction coil of the instrument alone being effective for use in obtaining a balance. The instrument weighs about a pound more than the old form, and the number of cells of the battery has not been reduced nor the over-all dimensions increased. It is claimed that tests recently made under severe service conditions show this form of meter to be superior to a bridge and galvanometer for the location of faults.

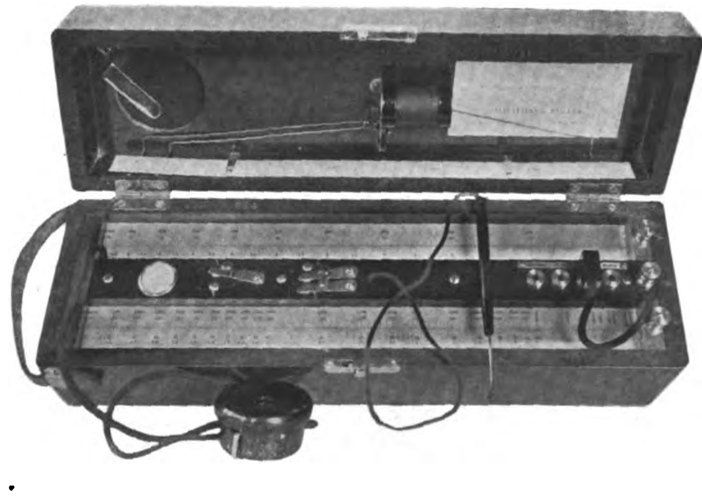


FIG. 3.—LATEST FORM OF HANCHETT OHMMETER.

THE MIDGET DYNAMO.

What is claimed to be the smallest dynamo on the market, having all the details of a larger machine, is shown by Fig. 4 herewith. The dynamo, it is said, follows the design of commercial machines in almost every detail, and is wound for two volts, four volts, six volts, eight volts and ten volts, the capacity of all the machines being ten watts. The pole-pieces are of soft cast iron carefully bored to fit the magnet core, which is of soft steel. The polar bore is accurately milled with special cutters, and the bearing seats being milled at the same time to the same circle insure the exact centering of the armature. The bearings are of cast brass, reamed to fit the shaft, and the bases or seats are milled with special cutters to the same arc as the polar bore. They are held firmly in position by a single screw in each. The commutator bearing carries two arms for supporting the brushes. The field coil is furnished with fibre heads and suitable connections to the brush-holders. The coil may be taken from the machine by simply removing the upper pole-piece. The armature has a lathe-turned steel shaft and laminated core with perforations for the winding and an 8-coil drum winding. After winding, the armatures are baked to expel all moisture from the insulation, and are then dipped while still hot in a special armature varnish and again baked. The machine is manufactured by the Elbridge Electrical Manufacturing Company, of Elbridge, N. Y.

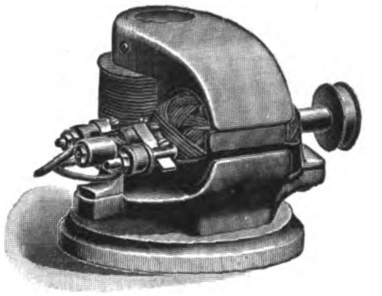
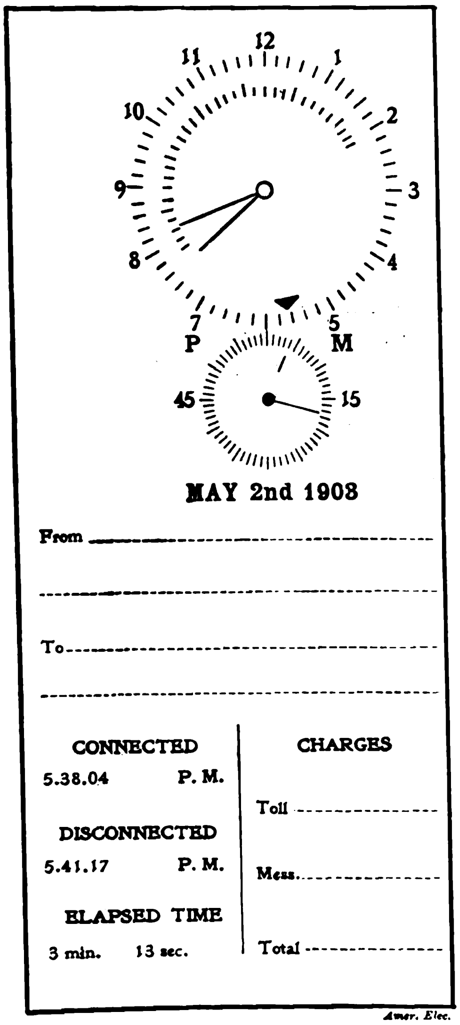


FIG. 4.—MIDGET DYNAMO.

AUTOMATIC TIME STAMP FOR TELEPHONE SWITCHBOARDS.

The calculating automatic time stamp, or "timometer," is an adaptation of the automatic time stamp to print not only the exact hour, minute and second, etc., but by the addition of very simple devices to automatically calculate and print the time elapsed or intervening between two successive imprints to the second. The instrument is adapted to be fitted into the telephone switchboard shelf, so that its base will be on a level with the shelf, the operating lever being underneath the same; or it may be placed upon a pedestal or other suitable support. The machine is practically noiseless in operation and prints on the upper side of the toll ticket. The ink ribbon is 24 ft. long and feeds automatically. The clock is said to be a good timepiece and is enclosed in a dust-proof case. It is not interfered with in the slightest degree by the operation of printing. The timometer may be arranged to print toll line slips or tickets of any width between 2¼ ins. and 4½ ins. The supporting base is 8⅜ ins. long and 4⅝ ins. wide and the clock case and its supporting arm and ink ribbon casing is 3 ins. wide and of the same length as the base. The greatest height above the surface of the base is 4½ ins. When it is not considered necessary to record and calculate closer than a quarter of a minute, the machine can be had without the second hand and dial printing parts. The clock case is fastened to the base by screw bolts and may be easily separated therefrom, thus making an inspection of the printing parts very easy. The visible hands of the clock move in unison with the time printing hands, and the setting of the former also sets the latter. The clock case is provided with a hinged door, which may be locked if need be to prevent any tampering with the clock.


12
11
1
10
2
9
3
8
4
7
5
P
M
45
15

MAY 2nd 1903

From ....

....

To..............................

....

CONNECTED		CHARGES
5.38.04	P. M.	Toll ....
DISCONNECTED		
5.41.17	P. M.	Mess..............
ELAPSED TIME		
3 min.	13 sec.	Total ....

Amer. Elec.

FIG. 5.—TIMOMETER TOLL SLIP.

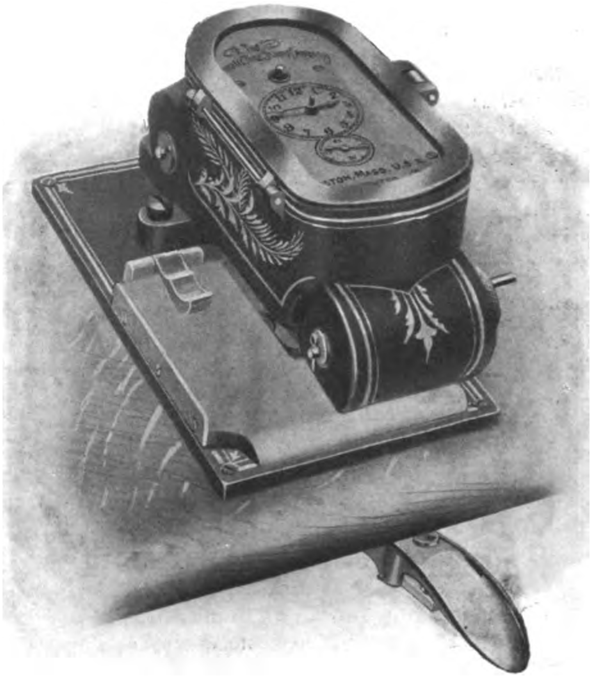
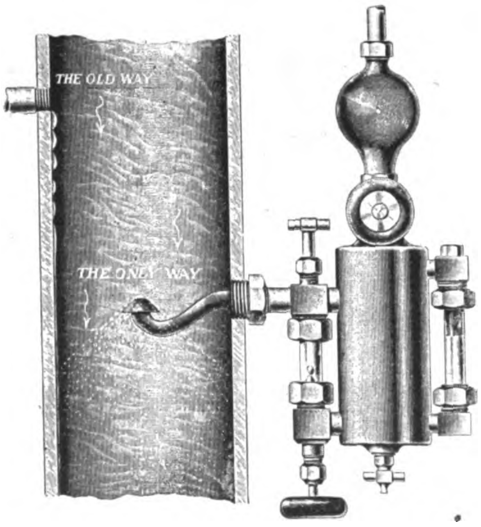


FIG. 6.—TIMOMETER.

Fig. 6 shows the instrument and Fig. 5 is a reproduction of one of the toll slips. The instrument is manufactured by the Automatic Time Stamp Company, of Boston, Mass.

CYLINDER OIL ATOMIZER.

The device shown by Fig. 7 herewith was designed to atomize the cylinder oil fed to an engine, so that the steam will carry it to all parts. It is claimed that by this means a saving in oil is accomplished and a perfect lubrication is maintained. The vaporizer consists of a bronze casting so shaped that the outlet is on a level with the inlet opening, one end of which is tapped into the steam pipe, as shown in the illustration, the other being tapped for the lubricator or oil pump. The action of the device is as follows: The oil flowing from the lubricator passes through the body of the vaporizer and is heated. By the time it reaches the outlet at the top of the cone it is said to be sufficiently thin and limpid to spread out over the surface in a thin film, as it reaches the lower edge of the cone it is carried along with the stream. This cone is always small enough to go through the opening in the steam pipe, and all the work necessary to install it is to unscrew the lubricator connection, tap the pipe for the atomizer, screw it into place, and then screw the lubricator back into the atomizer. The device is manufactured by the North Chicago Machine Company, North Chicago, Ill.



FIGI 7.—CYLINDER OIL ATOMIZER.

"STAR" SCREW-CUTTING ENGINE LATHE.

Fig. 8 herewith shows a new size of "Star" lathe, which has been designed to meet the demands of modern shop practice, for using high-speed tool steel, large feeds, big cuts, etc. This lathe has an actual swing of 15¼ ins. over bed, 8⅞ ins. over plain and compound rests and 6¼ ins. over rise and fall rest with 6-ft. bed, a distance between centers of 24 inches, and a net weight of 1,625 pounds. The head stock is heavy, has a hollow spindle with $1^9/_{16}$-in. hole, made from a crucible steel forging, and large bearings of phosphor bronze. The spindle is ground true and the bearings hand-scraped, to insure an accurate fit. The cone pulley has four extra wide steps for 2¼-in. belt. The ratio of back gearing is 9 to 1. The tail stock is the curved pattern which allows the compound rest to swing around parallel with the ways and over the base of tail stock with room to operate the feed-screw handle. The tail spindle has an improved locking device, which insures perfect alignment. The tail stock has a long bearing on the bed, and is locked to the bed in such a manner as to render it very rigid. The carriage is extra heavy, and is provided with "T" slots for bolting on angle plates, etc. It has a long bearing on the ways, and is gibbed to the bed, a new cam-locking device in the apron is provided for locking the carriage to the bed when using the cross feed. This device is operated by the same lever that operates the split nut on the lead screw, and the split nut cannot be engaged with the lead screw when the carriage is locked to the bed. The cross feed screw is graduated to read in thousandths of an inch. Either plain, compound or rise and fall rests are furnished as desired. The plain and compound rests are easily interchanged, one base and tool post answering for both. The compound rest has an extra long travel of 5¼ inches, and is capable of fine adjustment. The tool-post has a patented collar and shoe which exclude all dirt and chips, and admit of quick, easy and secure adjustment of the tool. Power is transmitted from the head spindle to the lead screw entirely by gears, and is arranged with three changes of feeds, fine, medium and coarse. These changes may be made while the machine is in motion by shifting the hand lever on the gear cage. An automatic stop is provided to stop the carriage at any point. A friction feed is provided by which both cross and longitudinal feeds are thrown in and out of contact by one hand knob on the apron, which operates the double friction clutch in connection with the worm gear. This construction prevents both cross and longitudinal feeds from being thrown in contact at the same time. The worm is keyed to the lead screw, which is splined, and simply acts as a feed rod, therefore the only wear on the threads of the lead screw is in screw-cutting. The range of screw-cutting is extra large, cutting all standard threads, including 11½ and 27, from 3 to 64 without compounding the change gears and nearly all threads by compounding. The lead screw has U. S. standard thread, and when desired, transposing gears and the International Standard Index are furnished. When cutting threads the hand lever on the gear cage points to "Threads." This connects the lead screw direct, and it is not driven through the train of gears in the gear cage. The automatic stop will not operate when the hand lever points to "Threads." The bed is broad, deep and heavy, and all other parts are proportioned throughout, making a very strong, stiff and rigid lathe. The countershaft has patent friction clutch pulleys, and also adjustable and self-oiling shaft bearings. The pulleys and friction bands are provided with self-closing oil cups. Each lathe is provided with a center rest, follower rest, large and small face plates, two point centers hardened and ground, full set of change gears, necessary wrenches, etc.

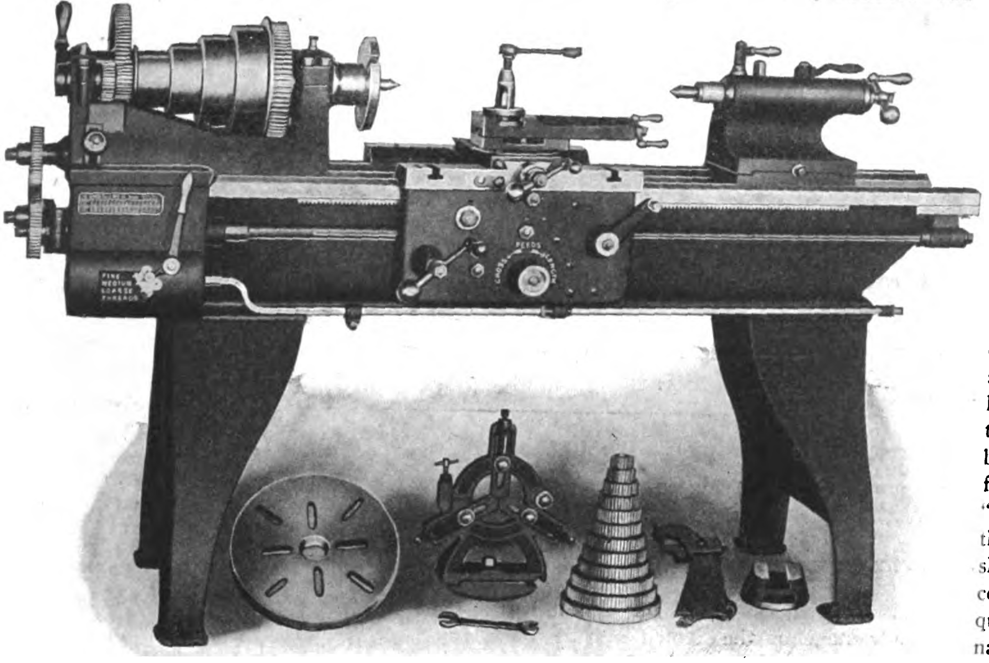


FIG. 8.—"STAR" SCREW-CUTTING ENGINE LATHE.

When desired a taper attachment is also furnished, which is secured to the back of the carriage, travels with same, and is always in position ready for use. It is connected to the bed by means of a screw clamp. A draw-in chuck attachment, which is suitable for the finest and most accurate service, is also provided. The split collets up to ¾ inch, and sleeve are made of tool steel, hardened and ground. This lathe is made by the Seneca Falls Manufacturing Company, Seneca Falls, N. Y.

THE ROBB-MUMFORD BOILER.

The accompanying illustrations show the Robb-Mumford internally fired boiler, which, although new to the American market, has been manufactured extensively for several years in British America.

The boiler consists of two cylindrical shells, the lower one containing a cylindrical furnace and tubes, and the upper forming a steam and water drum, the two being connected by two necks. The lower shell has an incline of about one inch to the foot from the horizontal, for the purpose of promoting circulation and draught. A steel casing, stiffened by angle irons and lined with asbestos air-cell blocks, forms the rear smoke box and return smoke flue between the lower and upper shells. The furnace is of the well-known "Fox" or "Morrison" corrugated type. The heads of the steam drum are spherical, and the tube sheets are stayed by the tubes so that, excepting the tube sheets, no staying is required. The gases, after leaving the furnace, pass through the tubes, and return between the lower and upper shells to the outlet at the front of the boiler.

The circulation of water inside the boiler is around the furnace and tubes, up the rear neck into the steam and water drum, where the steam is released, the water passing along the upper drum toward the front, and down the front neck. A semi-circular baffle plate, which is placed about half way around the furnace, causes the down-flowing water to circulate to the lowest part of the shell under the furnace. It will be seen by reference to Fig. 10 that the

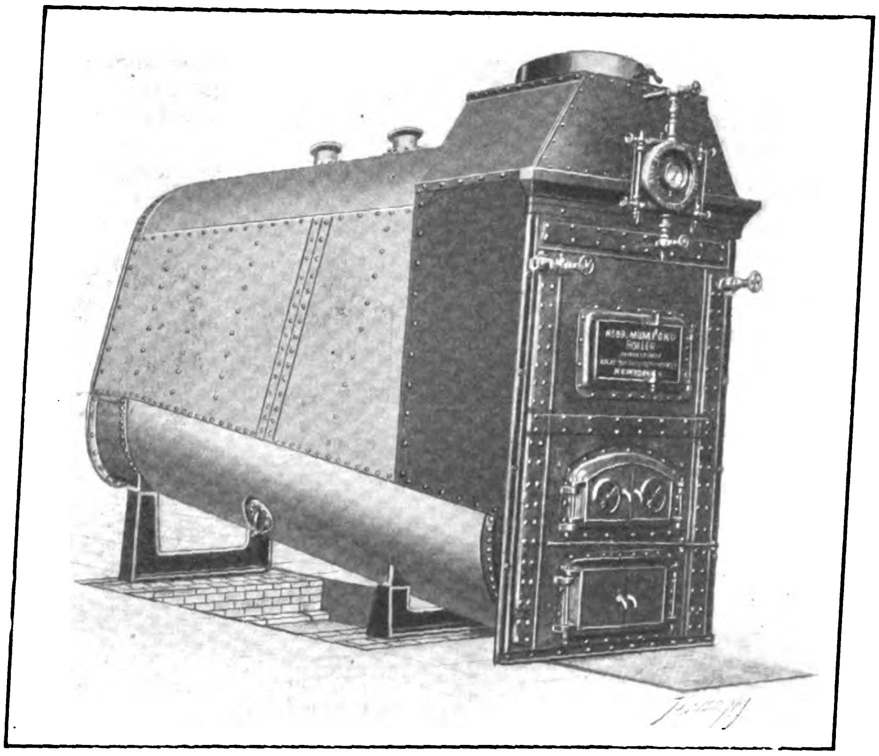


FIG. 9.—ROBB-MUMFORD BOILER.

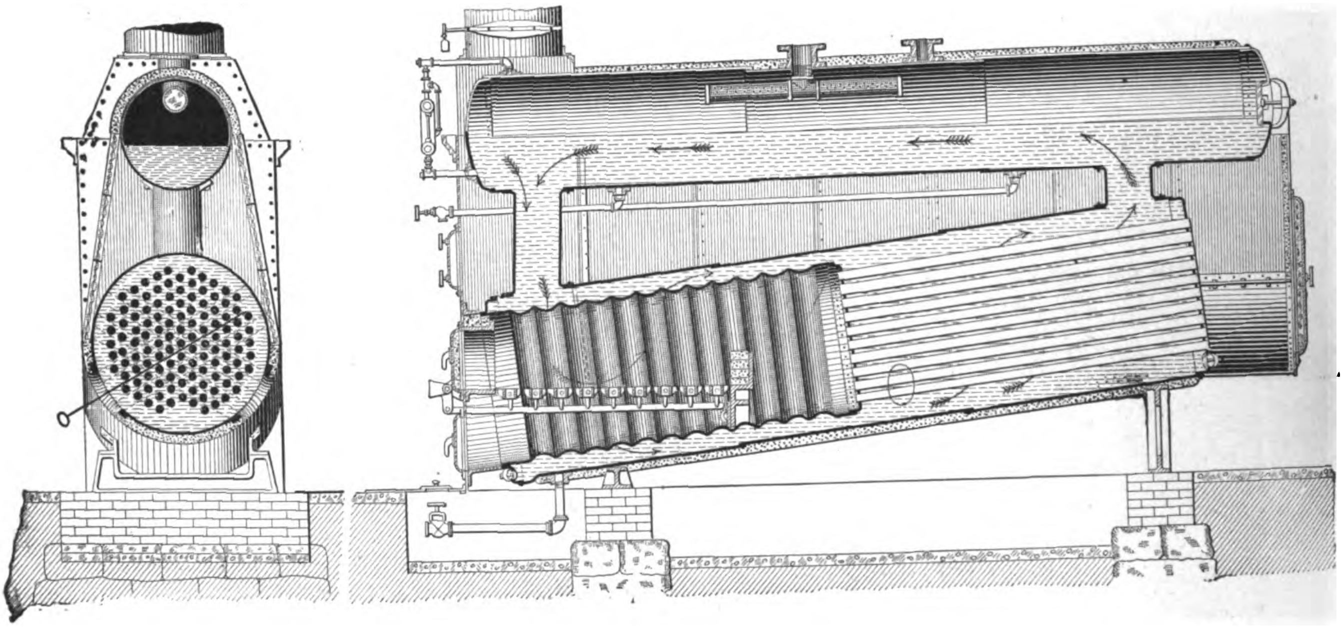


FIG. 10.—END AND SIDE ELEVATIONS OF ROBB-MUMFORD BOILER.

feed water enters the rear part of the upper drum, where it meets the current of hot water flowing toward the front, so that as it passes toward the front, the temperature is raised to that of the steam and water in the boiler, and an opportunity is given to drop any sediment or solvent impurities on the bottom of the upper drum, particularly in the pocket formed by a baffle plate, which is placed back of the front neck, and there is a blow-off outlet provided at that point. Another pocket for the deposit of sediment is provided underneath the furnace, with a blow-off, so there are practically two mud drums providing for the deposit and removal of sediment before the in-flowing water reaches the hot surfaces of the furnace and tubes. It is found by experience in using impure water, that it is easy to keep the boiler clean by the regular use of the blow-off cocks, and the usual washing out through the hand-holes at the front and back of the lower shell and through the man-hole in the upper drum. In addition, there are two large hand-holes in the shell at the rear of the furnace for cleaning between the tubes, the tubes being spaced in parallel diagonal rows, so that a bar may be passed through every row of tubes at the rear of the furnace, where scale will form, if at all. Owing to the rapid circulation of water around the upper part of the furnace and tubes, it is claimed scale will not form, except at the lower part of the boiler. In cases where exceptionally bad water is used, the furnace and tubes are bolted in, so that by removing a row of bolts passing through the front ring and an exterior angle iron ring, and another row through the rear tube sheet and ring, the entire furnace and tubes may be removed for inspection and cleaning.

Every part of the boiler is said to be open to inspection. A large space is provided under the shell, so that a man may pass under and see the entire lower half of the shell; the upper half of the shell, drum and necks being open to inspection through the front and rear doors, and, if necessary, the side casings may be removed. A man-hole is provided in the upper drum and numerous hand-holes in the lower drum, so that the interior of the boiler may be readily examined.

It is claimed for this boiler that it has the advantage of the Scotch Marine and similar types of internally fired boilers, without the large diameter of shell, thick plates and expensive combustion chamber, giving the lighter weight, less floor space and more perfect circulation of the best boilers of the sectional or water-tube type, but avoiding the large number of hand-holes and joints usually necessary in boilers of the sectional type. As the fire-box is internal, surrounded entirely by water, there is said to be no loss of heat, either by radiation or air leakage.

A battery of 1,000 horse-power occupies a space of about 32 feet in width by 23 feet in depth and 14.25 feet in height. Each unit is entirely distinct, and may be completely isolated for cleaning, inspection or repairs. The manufacturers for the United States are the Robb-Mumford Boiler Company, Incorporated, New York and Boston.

A NEW CABLE CLIP.

Fig. 11 herewith shows the H-P cable clip, which is manufactured by J. S. Barron & Co., of New York City. It is a simple device and easily applied. It is made in one piece and hence there are no parts to become detached or lost, and being made of zinc it is, of course, rustless. In applying the hanger, the circular enlargement is held against the cable with the left-hand while the other end is wound around and passed through, as shown by Fig. 12. Is is then wound around again, put through the upper slot and carried over the suspension wire, as shown by Fig. 13, after which it is bent and hooked into the upper slot, as illustrated by Fig. 14, which shows the cable clip in position on the suspension wire. The hangers are made in all length from 10½ inches upwards, the widths being the same for the different sizes.

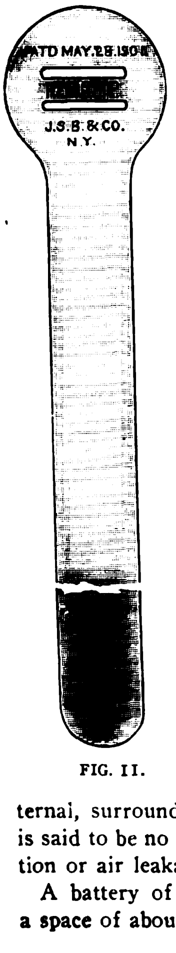


FIG. 11.

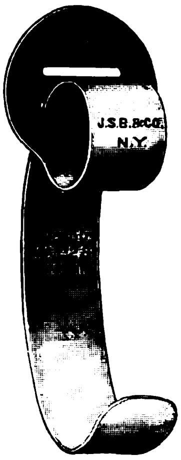


FIG. 12.

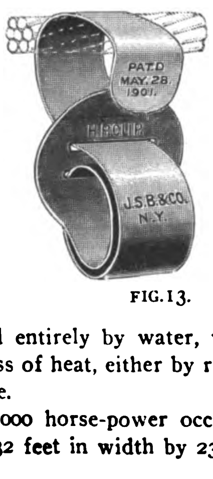


FIG. 13.

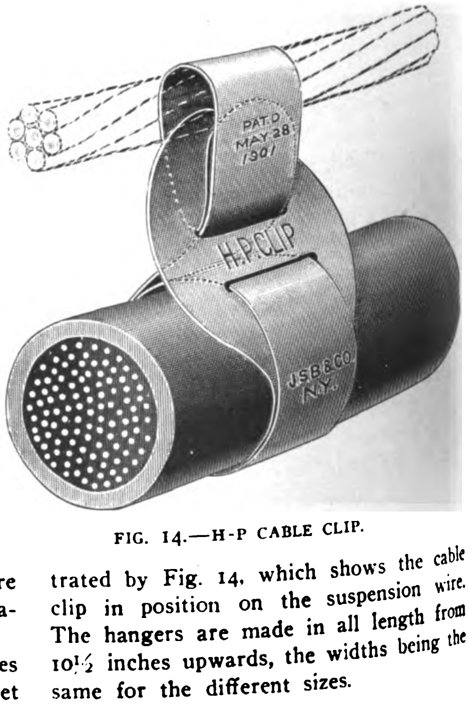


FIG. 14.—H-P CABLE CLIP.

GAS ENGINE IGNITER.

Practically all the users and manufacturers of gas engines have accepted the electrical as the most satisfactory method of igniting the charge in the cylinder, while the clumsy hot tube and open flame have been almost entirely discarded. In this work the primary battery has held sway for some time, but is now gradually giving place to the spark dynamo. Fig. 15 shows a gas engine igniter brought out by the Holtzer-Cabot Electric Company, of Boston, Mass. This was designed especially for very large stationary engines, and on account of its large output has been found to operate satisfactorily with some forms of jump spark coils. Possessing the advantages of the magneto type, it has been found also useful on automobiles, where there is sufficient space to permit of its use. It will be noted that the brush-holder is unusually large and admits of a large brush, with a consequent longer wear than any of the pencil type. The permanent magnets are aided by two coils in series with the armature, and the current flowing through the armature also flows around these coils in such a direction as to increase the magnetization in proportion to the flow of current. By this means, the field is strengthened when the load comes on the igniter, and a much greater output is obtained than would be othewise possible. Fig. 22 shows the automatic switch for gas engines, with which it is necessary to use batteries in starting. On starting from rest, the batteries are in circuit with the sparking points of the engine, and as soon as the igniter has reached sufficient speed to create a spark part of its output energizes the electromagnets which draw the soft iron armature, thereby opening the battery circuit and closing the igniter circuit. Fig. 16 shows the diagram of connections for the magneto igniter with the automatic switch.

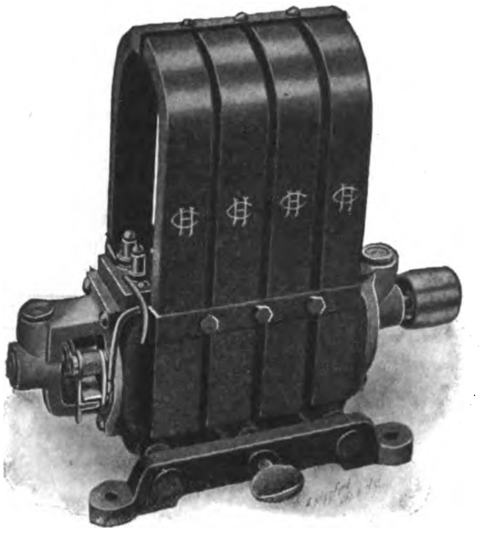


FIG. 15.—GAS ENGINE IGNITER.

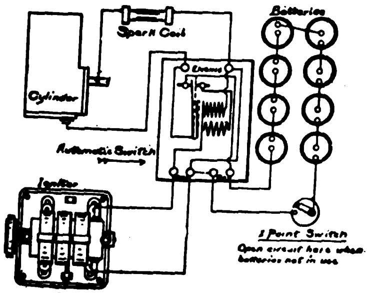


FIG. 76.—DIAGRAM OF CONNECTIONS.

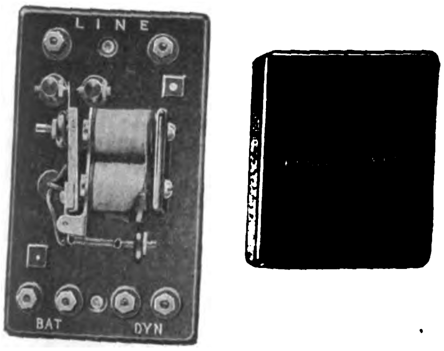


FIG. 17.—AUTOMATIC SWITCH.

A NEW AUTOMATIC ELECTRIC PUMP.

The accompanying illustration shows a new electric pump manufactured by the Automatic Electric Pump Company, of New York City, designed by the builders after many years' experience with this class of machinery. The water cylinder as is of the standard double-acting duplex type used in pumping machinery for many years; the pistons have flexible packing which may be cheaply and quickly renewed when necessary. The mechanism for driving the pistons, and for transmitting the power of the motor to the pump, is enclosed in a case containing oil enough to run a year without refilling. By this means ample, positive and permanent lubrication of all working parts is automatically secured. The motor, as may be seen, is connected directly to the pump, without the intervention of belts, spur-gearing, or other devices. As illustrated very clearly in Fig. 19, the power of the motor is transmitted through a shaft and double worms to double worm gears, and from cranks upon one of these gears to the yoke-pieces which are connected to the piston rods. The mechanism is such that it dispenses with any necessity for attention or mechanical skill, which especially suits it for domestic service. These worms reduce the high speed of the motor to a moderate speed for the pump, thus insuring a smooth, noiseless pumping action. The motor is connected to the pump by means of a universal compensating clutch, securing flexibility to the motor and worm shafts, and avoiding friction loss. An important feature in the installation of these pumps is the electric switch placed at the tank for starting and stopping the pump automatically. The tank is thus kept full without requiring the services of an attendant. Of course this is only necessary where automatic operation is required. Every pump comprises a bed plate, with the pump, motor and mechanism, properly assembled and bolted thereon, ready for starting, and is mounted upon four legs ready to be set in place where desired without any foundation or preliminary work or expense. For this reason the pump as shipped can be located, connected up and started as soon as received without any delay, labor or expense other than that required for the requisite wiring and piping.

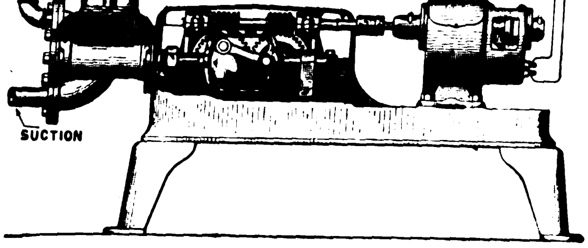


FIG. 19.—AUTOMATIC ELECTRIC PUMP.

A NEW ENCLOSED FUSE.

The accompanying illustration (Fig. 18) illustrates the latest enclosed fuse which has been brought out. As the illustration clearly shows, the fuse terminals consist of simple suitable wires of sufficient length to enable one to insert the fuse in an ordinary fuse block irrespective of the distance between the terminal posts to which it must be connected. This fuse is made in all of the usual capacities by the McBride Manufacturing Company, Detroit, Mich., who claim that it is entirely noiseless and absolutely reliable under all conditions, and that it meets the published requirements of the National Board of Fire Underwriters.

FIG. 18.—M'BRIDE ENCLOSED FUSE.

CIRCUIT-BREAKER FOR POLYPHASE MOTORS.

Polyphase motors are for the most part so admirably built, and their ability to withstand overloads is so well known that these advantages often cause them to be carelessly started and often times abused. While this may not result in the immediate injury of the motor, it causes disturbances in the voltage of the circuit, and the undue waste of energy may result in serious injury to the machinery operated by the motor. In order to guard against this, the Cutter Company, of Philadelphia, has brought out a new type of I-T-E circuit-breaker for use in connection with polyphase motors. The heavy starting current required by many types of polyphase motors has heretofore militated against the use of overload circuit-breakers for their protection. This difficulty is overcome by making use of the connections shown by Fig. 20 between the auto-converter and the circuit-breaker, so that the latter will be included in the circuit of the motor only when the switch of the auto-converter is in running position. When the circuit-breaker is connected in this manner, it will not be acted upon by the currents which pass while the switch is in the starting position. If, however, the switch should be thrown in the running position at once, or before the motor has come up to speed, the circuit-breaker will open under the resulting overload, as it will also should the motor be unduly loaded. The device also insures the opening of all phases simultaneously when the circuit of any one phase is interrupted, as by the blowing of a fuse either at the motor or somewhere in the circuit supplying it.

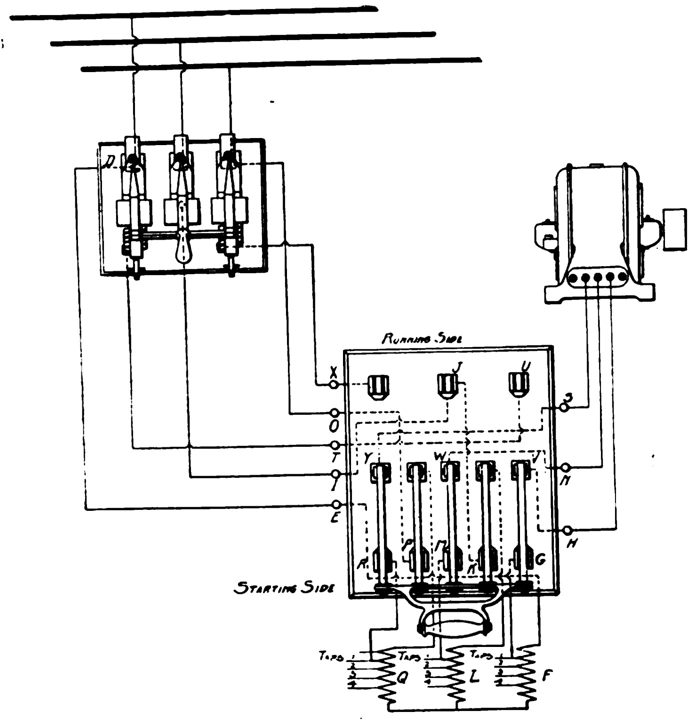


FIG. 20.—CIRCUIT-BREAKER FOR POLYPHASE MOTORS.

STATIONARY GASOLINE ENGINE.

Fig. 21 herewith shows a small gasoline engine made by the Lowell Model Company, of Lowell, Mass. The engine develops one-half horse-power at a speed of 500 r.p.m., and is suitable for running light machinery. It operates on the four cycle principle, and can be used with either gasoline or illuminating gas. The vibration is said to be very slight and the noise of the exhaust is considerably reduced by a muffler. The cylinder, which is made of cast iron, is firmly bolted to the base and water jacketed. The valves are placed in the cylinder head, which is also water jacketed. The bearings are cast on the base and are parted on an angle of 45°. The crank shaft is of drop-forged steel with a bronze connecting rod. The piston and rings are of cast iron. Two heavy balance wheels are used, one of which carries the governor and the other a belt drum. Ignition is by electric spark operated by the piston. The company can also furnish castings of the various parts to those who wish to construct the engine themselves.

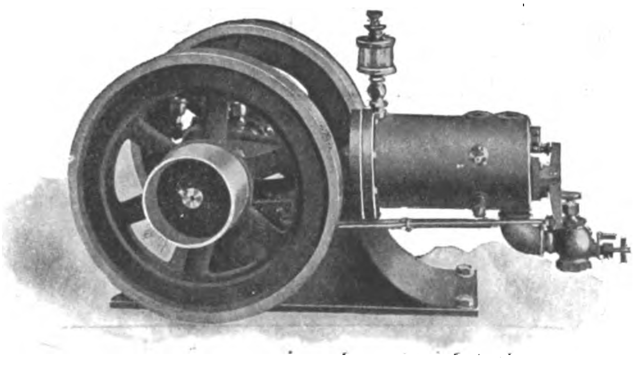


FIG. 21.—LOWELL GASOLINE ENGINE.

NEW BOOK.

The Elements of Electrical Engineering. By Tyson Sewell. London. D. Van Nostrand Co. Buckram, 332 pages, 5½ ins. x 8 ins.; 204 illustrations. Price, $3.00.

As explained in the preface, the book is based upon a series of lectures given to classes at the Polytechnic, Regent Street, London, and the author's aim is to introduce the student by easy stages into the study of electrical engineering. First, the meaning of the principal units used in electrical work is explained and their relations to each other shown, after which a number of instructive and useful illustrative examples are given, followed by a chapter on series and parallel circuits. The next chapter is devoted to the heating effects of current, followed by two more on magnetic effects and the magnetization of iron. Two chapters are devoted to electro-chemistry, primary and secondary batteries, and four to measuring instruments and testing. In the next two chapters is given a description of various forms of arc lamps, together with a most excellent detailed account of the manufacture of incandescent lamps. The rest of the book is devoted to dynamos and motors. Throughout the book numerous examples are given to show the application of the principles and methods explained, wherever it can be done without necessitating the use of advanced mathematics. The style of the author is extremely simple and concise, and his explanations unusually clear, which together with the fact that no difficult mathematics are encountered, make the reading easy and pleasant, and place the book within the reach of those who have not had the advantages of a mathematical education. Altogether, it is an excellent work, and the author is to be congratulated on the manner in which he has presented the matter of which he treats, and the book should commend itself not only as a text-book for students but also as a handy reference work for practical men.

OBITUARY.

JAMES REILLY, president of the James Reilly's Sons Company, New York, died recently in this city.

LYMAN T. LAWTON, formerly president of the Automatic Lighting Company, and of the Connecticut Telephone & Electric Company, Meriden, Conn., died recently at the age of 55 years. Mr. Lawton was widely known as a prolific electrical inventor.

S. MORGAN SMITH, president of the S. Morgan Smith Company, York, Pa., died recently at Los Angeles, Cal., whither he had gone in the hope of regaining his health, which had become seriously impaired. Mr. Smith's company is one of the largest manufacturers of water-wheels in the United States, and the prosperous development of its business was largely due to his unusual ability. and energy.

WILLIAM WARREN CARD, second vice-president of the Westinghouse Air Brake Company, was run down and killed by a Wilkinsburg trolley car on April 4. The accident occurred in front of Mr. Card's residence and was due to his alighting from a car going in one direction and walking from behind it directly in front of another car going rapidly in the opposite direction. He died within a few hours after the accident. Mr. Card was in his 72nd year and was prominent in railroad circles throughout the United States.

PERSONAL.

MR. W. P. CONOVER, JR., was elected a director of the Philadelphia Electric Company at the annual meeting of the company held recently.

MR. ARCHIE KELLY, a member of the consulting engineering firm of Lester, Taylor, Kelly & Hide, of Liverpool, is visiting this country.

MR. JOHN R. GEARY, of the General Electric Company's staff, has been given the representation of his company in Japan, and is already on the way to Yokohama to assume his new charge.

MR. G. P. ROBINSON, who has been connected with the Central Union Telephone Company, of Chicago, for some time past, has been appointed traffic manager of the Sunset Telegraph & Telephone Company's system on the Pacific Coast.

MR. R. H. PEIRCE, of Peirce, Richardson & Neiler, Chicago, will establish a branch office for his firm in Boston and take charge of the office personally. Mr. S. G. Neiler will remain in charge of the Chicago office.

MR. H. C. PATTERSON has entered the consulting engineering field, with offices at 17 State Street, New York. Mr. Patterson will cover the electrical, mechanical and hydraulic branches of engineering.

MR. J. W. HOLMAN, recently of *The Engineering and Mining Journal*, and Mr. G. W. Scott, recently of the *Mining and Scientific Press*, have purchased the *Western Mining World*, of Chicago, which will be known hereafter as the *Mining World*.

MR. B. A. BEHREND, chief engineer of the Bullock Electric Manufacturing Company, while on a visit to California recently, delivered two lectures to the students in electrical engineering at Stanford University on "The Design of Alternating-Current Machines."

MR. F. G. BAUM, of the electrical department of Stanford University, has been appointed assistant to Mr. L. M. Hancock, chief engineer of the California Gas & Electric Corporation. Mr. Baum will have charge of the electrical engineering department of the system, but for the present will continue his classes at the University.

MR. W. C. ANDREWS, who has been associate editor of the *Street Railway Journal* for the past two years, has been appointed eastern representative of the firm of E. P. Roberts & Co., consulting engineers, of Cleveland. The firm will open a New York office of which Mr. Andrews will have charge.

MR. ERNEST F. SMITH, who has been for several years assistant to the chief operating engineer of the Edison and Commonwealth Companies, of Chicago, has been elected vice-president and general manager of the St. Joseph Boat Manufacturing Company, St. Joseph, Mich. Mr. Smith will retain his position with the Edison and Commonwealth Companies.

TRADE PUBLICATIONS.

FAN MOTORS. Western Electric Company.—The 1903 edition of this company's fan motor catalogue, which is executed in the usual elaborate style.

INCANDESCENT LAMP PRICE LIST. Germania Electric Lamp Company, Harrison, N. J.—A pocket folder containing a price list of Germania lamps in all candle-powers and types, together with some strong claims as to the qualities of the lamp.

TRANSFORMER INSULATION. Fort Wayne Electric Works.—This is publication No. 5002 in which is described the construction of Fort Wayne transformers with special respect to the method of insulating the coils.

ELECTRICAL NOVELTIES. The Swett & Lewis Company, Boston, Mass.—This is bulletin No. 32, devoted to X-ray tubes, vacuum electrodes, for high-frequency work, electric heating appliances, spark regulators, induction coils, etc. The pamphlet is liberally illustrated and each of the specialties is fully described.

SIXTEEN ALL-WAYS. The Sterling Electric Manufacturing Company, Warren, Ohio.—An artistic folder devoted to the presentation of claims for the Sterling "Special" incandescent lamp, which, it is explained, gives 16 candle-power in all directions. The title of the pamphlet is a clever paraphrase, being inscribed beneath the picture of a maiden presumably blessed with perennial youth.

PACKING GAS ENGINE CYLINDER HEADS. H. W. Johns-Manville Company, New York.—A pocket-size folder containing complete instructions for packing cylinder heads of gas engines with "Mobilene," which is a special packing made by the Johns-Manville Company for this purpose. The directions are both comprehensive and readily comprehensible.

IMPERIAL PNEUMATIC TOOLS. Rand Drill Company, New York.—This is circular No. 2, containing illustrations of pneumatic tools of all sorts, together with condensed data relating to the various tools. The list of tools here shown includes imperial air compressors, pneumatic hammers, pneumatic drills, bolt drivers and motor hoists.

MECHANICAL FORCED DRAFT. Buffalo Forge Company, Buffalo, N. Y.—A very tastefully executed pamphlet of pocket size, containing illustrations of the various types of combined fans and engines and fans and electric motors, draft dampers, etc., which form parts of the company's forced draft system, and also two views of a boiler plant, one showing the plant with chimney draft and the other with forced draft, the comparison being a striking one.

TUERK CEILING FANS. Hunter Fan & Motor Company, Fulton, N. Y.—This is the 1903 catalogue of the well-known Tuerk Alternating-current fan and is one of the most handsomely executed specimens of trade literature that has appeared recently. The various forms of Tuerk fan are illustrated and described, and the different parts of the motor and casing are illustrated separately. The book is printed on a delicate tint of egg-shell paper, which gives it a most attractive appearance.

DENTAL LATHE MOTORS. The Holtzer-Cabot Electric Company, Boston, Mass.—A pocket-size pamphlet devoted to small direct-current and alternating-current motors which are designed especially for dental work. The motors are entirely enclosed and both ends of the shaft are extended beyond the bearings and equipped with grinding, buffing and polishing attachments. These little machines are also particularly well adapted to jewellers' work and similar service involving the grinding and polishing of small pieces.

TRADE MARKS. Luther L. Miller, Chicago.—Two handsome brochures, one devoted to a discussion of trade marks from the advertiser's standpoint and the other containing a summary of the laws of this country and the principal foreign countries relating to trade marks. The latter of the two books is especially valuable to those whose business is such as to make the question of trade marks an important one, and both books are of interest to any one at all concerned with the subject.

DIRECT-CURRENT GENERATORS. Sprague Electric Company, New York.—Bulletins Nos. 101 and 102, the former being devoted to the well-known Lundell single-field-coil type of machine and the latter to the Lundell split-pole multiple field coil machine. Both of the bulletins are handsomely executed in conformity with the Sprague Company's advertising methods, and the various parts of the machines, as well as the complete structures, are shown by means of clean-cut halftone engravings. The usual tables of dimensions, weights and speeds are, of course, included.

BUSINESS NEWS.

ROSSITER, MacGOVERN & CO., New York, has removed its general offices from 141 Broadway to 6 and 10 Battery Place.

NEWTON ENGINEERING COMPANY, Milwaukee, Wis., has acquired the electrical and mechanical engineering business of the late A. M. Pattitz.

KEYSTONE LUBRICATING COMPANY, Philadelphia, has established a new office in the Postal Telegraph Building, 253 Broadway, which is in charge of Mr. Lewis F. Hopper.

CENTRAL ELECTRIC COMPANY, Chicago, reports that more orders for Stombaugh guy anchors have been received this spring than ever before, which, of course, indicates the increasing popularity of these very convenient appliances.

BRODE ELECTRIC COMPANY, Los Angeles, Cal., has taken out papers of incorporation and has also moved into new quarters at 306 South Los Angeles Street, where much better facilities will be enjoyed than heretofore.

THE FAHNESTOCK TRANSMITTER COMPANY, 74 Cortlandt Street, New York, desires to call attention to the fact that they are the manufacturers of the new telephone transmitter described on page 206 of the April number of this paper.

THE ELECTRIC APPLIANCE COMPANY, Chicago, is especially enthusiastic just now over the large sales of the new glass-case Gutmann alternating-current wattmeter. This is said to be the smallest and lightest weight instrument of its class thus far built.

ABBOTT ELECTRIC COMPANY, Boston, Mass., has established an electrical engineering department in charge of George Calloway, lately of the General Electric Company, for the purpose of contracting for complete electric light and power plants.

EDWARD S. HALSEY, Chicago, has moved into a new factory at 96 Chicago Avenue, which is thoroughly equipped for manufacturing his mercury bath wattmeter. Mr. Halsey states that he is now in position to fill orders for meters of small and moderate sizes promptly.

H. S. BURROUGHS, consulting engineer, has removed his office from 27 William Street to 19 William Street, New York, and in addition to his consulting work is now manufacturers' agent for several high grade electrical specialties, among which may be mentioned the Columbia enclosed arc lamp.

THE E. G. BERNARD COMPANY, Troy, N. Y., has removed its office and supply department to 1918 Sixth Avenue, where nearly twice as much floor space is available as the company previously had at the Fulton Street store. The company has also found it necessary to make additions to its factory space and facilities on account of increased business.

THE STILWELL-BIERCE & SMITH-VAILE COMPANY, Dayton, Ohio, has established a branch house at San Francisco, Cal., in charge of George W. Ingils and Edward G. De Wald. Mr. Ingils will handle the pumping machinery and air compressor branches, and Mr. De Wald the turbine water wheel department of the business. The new offices are at 11 and 13 First Street.

CARL G. M. MILLER & CO. is the name of a firm which has been established at 141 Pearl Street, Boston, Mass., for the purpose of dealing in electrical machinery and specialties. Mr. Miller was connected with the Chase-Shawmut Company for nine years and has had extensive experience in the line of work to which the new firm will devote its energies.

THE NORTON ELECTRICAL INSTRUMENT COMPANY, Manchester, Conn., has moved into its new factory, which is equipped with the most modern facilities. The offices, assembling room and calibrating room are located on the first floor and the machine shop is on the second floor. The machinery throughout the factory is operated by electric power and all of the equipment is in keeping with the most modern practice.

BUFFALO FORGE COMPANY, Buffalo, N. Y., has established a new branch office in Detroit, Mich., at 1409 Majestic Building. The business of this district will be in charge of Mr. H. M. Brightman, as heretofore. The company has removed its Pittsburg branch office from 516 Fitzsimmons Building to 607 House Building, in order to obtain better facilities for taking care of the business in that district. Mr. H. D. Wilson continues in charge of the Pittsburg office.

WESTERN ELECTRIC COMPANY recently bought an extensive tract of land in South Chicago upon which to establish additional shop buildings. The new purchase comprises 109 acres of ground located at the intersection of the Chicago, Burlington & Quincy Railroad and the Chicago & Western Indiana Belt Line. It is stated that the company will put up buildings to cost over $1,000,000, exclusive of the cost of the machinery to be installed. The new shops will include an extensive cable plant.

THE BROWN-CORLISS ENGINE COMPANY, Corliss, Wis., continues to have a hard time in keeping abreast of its orders. Numerous sales in eastern territory have been made recently, which include a 16 and 30x42 horizontal cross-compound and an 18 and 34x36 vertical cross-compound engine to the Middlesex & Somerset Traction Company, New Brunswick, N. J., and a 26 and 42x42 tandem compound engine to the American Locomotive Company, Dunkirk, N. Y.

LOCKE INSULATOR MANUFACTURING COMPANY, Victor, N. Y., reports the following recent installations of Victor insulators on high potential lines: No. 329 insulators by the Guanajuato Power & Electric Light Co., Mexico, on steel towers and all iron cross-arms, 60,000 volts potential; No. 329 insulators by the Washington Water Power Co., Spokane, Wash.; Nos. 29 and 31 insulators by the Pueblo & Suburban Traction & Lighting Co., Pueblo, Colo.

THE AMERICAN TOOL WORKS COMPANY, Cincinnati, Ohio, announces that recent changes in the personnel of its management have placed the business in the hands of Franklin Alter, president; J. B. Doan, general manager; Henry Luers, secretary and treasurer, and A. E. Robinson, general superintendent. The business transacted during the month of February was next to the largest done in any month in the history of the establishment.

STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago, reports that its business is such as to render it necessary to increase the factory facilities both at Chicago and Rochester. The factory at Chicago is turning out 1200 instruments a day, and even at that rate it is extremely difficult to keep up with orders. The company has already begun the erection of a second factory in Rochester, N. Y., which will have 200,000 square feet of floor space and will be equipped with facilities for turning out 2000 instruments a day.

A HUGE CONTRACT.—Probably the largest contract ever placed for electrical generators for use west of the Rocky Mountains has been awarded by Stone & Webster, of Boston, managers of electric power, traction, and lighting plants along Puget Sound, to the General Electric Company. The order is for six machines, two to be furnished to the Tacoma Industrial Company and four to the Pierce County Improvement Company. The generators will be three-phase, 60-cycle machines, of 3500 kilowatts capacity each, at 2300 volts and 225 r.p.m. Deliveries will commence next September.

I. P. FRINK, New York, the well-known manufacturer of reflectors and electric light fixtures, recently received the following letter which speaks for itself:

"Answering your inquiry of the 26th in regard to the Church electric light fixtures bought of you, I would say that five of the seven churches here are lighted with your fixtures, and all the different congregations are well pleased with the fixtures. Some time ago a minister was here who had charge of some mission in India. He was so strongly impressed with the lighting by your fixtures that he said he would order some fixtures to be sent to India. Very respectfully,

(Signed) C. E. Pierce, Pur. Agt."

THE STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., at the recent meeting of its Board of Directors, elected the following officers: W. Murray Crane, president; Dr. F. A. C. Perrine, 1st vice-president; M. D. Barr, 2nd vice-president; S. N. Hammill, 3rd vice-president; W. W. Gamwell, treasurer; W. S. Westover, secretary. The company reports a continuation of brisk business. Among recent sales might be mentioned a 1000-kw. alternator and seven 150-kw. booster sets to the New York Edison Company; three 550-kw. synchronous motors to the Municipal Gas Company, of Albany, and an equipment of fifty-two street railway motors to the Sheboygan (Wis.) Light, Power & Railway Company.

ALLIS-CHALMERS COMPANY, Cnicago, at the meeting of the Board of Directors held in New York on April 15, declared the regular quarterly dividend of 1¾ per cent. on its preferred stock. The company states that the volume of business on its books far exceeds that at any previous time since the organization of the company. Recent sales include a 34 and 70x54 horizontal cross-compound to the Southside Elevated Railway Company, Chicago; two 34 and 68x48 cross-compound condensing engines to the International Traction Company, of New Jersey, and one 26 and 58x60 cross-compound condensing engine to the Washburn-Crosby Company, Minneapolis, Minn. All of these were of the Reynolds-Corliss type.

THE KENNICOTT WATER SOFTENER COMPANY, Chicago, reports a large demand for its apparatus, notwithstanding the fact that this has been on the market less than two years. The company has under construction machines which will have an aggregate total capacity of 20,000,000 gallons of water. These include ten outfits for the Pittsburg & Lake Eric Railroad, and orders have also been received from the Union Pacific Railway for twenty-five outfits varying in capacity from 10,000 to 15,000 gallons an hour. The latter company was one of the first of the large railway systems to try the Kennicott method of softening water, and it has thus far given orders, it is stated, for plants sufficient to equip about three-fourths of its entire length of road bed.

PRODUCER GAS POWER PLANT FOR GREECE.—The favor in which American power apparatus is held by foreign capitalists is well illustrated in the case of a recent light and power enterprise at Tripolis, Greece. The high price of coal at this location has induced the promoters to install gas power, the fuel for the producer plant to consist entirely of native lignite, which has been found to yield a gas of good quality and quite suitable for power work. The plant will have an initial capacity of about 125 horse-power, comprising two Westinghouse three cylinder vertical gas engines each belted to a generator, which will supply the present demand for current. The engines will be supplied with fuel gas from Taylor producers, furnished by R. W. Wood & Co.

THE ELECTRIC STORAGE BATTERY COMPANY, of Philadelphia, has brought out a new battery for gas engine ignition purposes. The great increase in the use of gasoline vehicles convinced the company that a reliable sparking battery, which will furnish a "fat" spark will be greatly appreciated, hence the new storage cell, which is built in several sizes. The company has added a number of new Exide battery depots to the list of stations hitherto announced, the complete list at present embracing the following stations: New York, No. 148 West 18th St.; Philadelphia, No. 250 N. Broad St.; Boston, No. 39 Stanhope St.; Buffalo, No. 200 Pearl St.; Chicago, No. 264 Michigan Blvd.; St. Louis, No. 3937 Olive St.; Rochester, No. 158 South Ave.; Toledo, No. 715 Jefferson St., and Detroit, No. 265 Jefferson Ave.

THE STANDARD PAINT COMPANY, New York, recently gave a jolly house-warming to their employees in the new factory building at South Bound Brook, N. J. It is unnecessary to state that those who attended thoroughly enjoyed the occasion. Pres. Ralph L. Shainwald graced the occasion with his presence and from all sides received congratulations upon the great success evidenced by the necessity for the new plant. The visitors from New York and neighboring New Jersey towns were numerous. The Standard Paint Company was organized in 1886, and the first factory was erected at Bound Brook, N. J., on a part of the site of the present works. This building has long since disappeared, and the site is now occupied by a brick and iron structure forming a part of the present mills. As an evidence of the expansion of the business it can be said that there has not been a time during the past five years when the company has not been behind its orders. Within the last two years the pressure upon the manufacturing facilities have been so extraordinarily great that the present enlargement was rendered imperative.

THE LOMBARD WATER WHEEL GOVERNOR COMPANY, of Boston, Mass., reports a good demand for its water-wheel governors. Recent orders include the following: Cascade Electric Co., of Berlin, one Type B governor; Redlands Electric Lt. & Power Co., of California, one Type F governor; Brattleboro Gas Light Co., Brattleboro, Vt., one Type O governor; Ware Shoals Mfg. Co., Laurens, S. C., two Type B governors and four hydraulically balanced relief valves; Nasonville Woolen Co., Nasonville, R. I., one Type D governor; Athens Electric Railway Co., Athens, Ga., one Type D governor; Ludlow Mfg. Associates, Ludlow, Mass., one Type D governor; Sebasticook Power Co., Sebasticook, Me., three Type D governors; Niagara Falls Power Co., Niagara Falls, N. Y., one Type G governor; Lynchburg Water Power Co., Lynchburg, Va., two Type B governors; two Type P governors and four electric speed controllers; Public Works Co., Bangor, Me., two Type B governors with electric speed controllers; Zanesville Elec. Lt. & Power Co., Zanesville, Ohio, two Type B governors with electric speed controllers; Canadian Elec. Lt. Co., Levis, Que., one Type B governor; Victor M. Braschi & Bro., City of Mexico, one Type F governor; Sacramento Electric, Gas & Rwy. Co., one Type B governor and electric speed controller; Valley Counties Power Co., of California, two Type D governors with electric speed controllers.

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All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Faul Railway.

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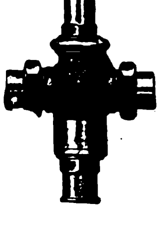
APPLIED WITH A BRUSH

BELTS WON'T SLIP
IF YOU COAT THE PULLEY WITH
WARREN'S PULLEY COVER PUT ON WITH A BRUSH.
125 SQ. FT. $12.00; 40 SQ. FT. $5.00. TO-DAY IS A GOOD DAY TO ORDER
THE WARREN COMPANY, INC., MFRS., 253 N. FRANKLIN ST., CHICAGO, ILL.



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THE MASON REGULATOR CO., Boston, Mass., U. S. A.

American Electrician.

Vol. XV. New York, June, 1903. No. 6.

A VERY MODERN CENTRAL STATION OF MEDIUM SIZE.

THE CENTRAL STATION AT DE KALB, ILL.

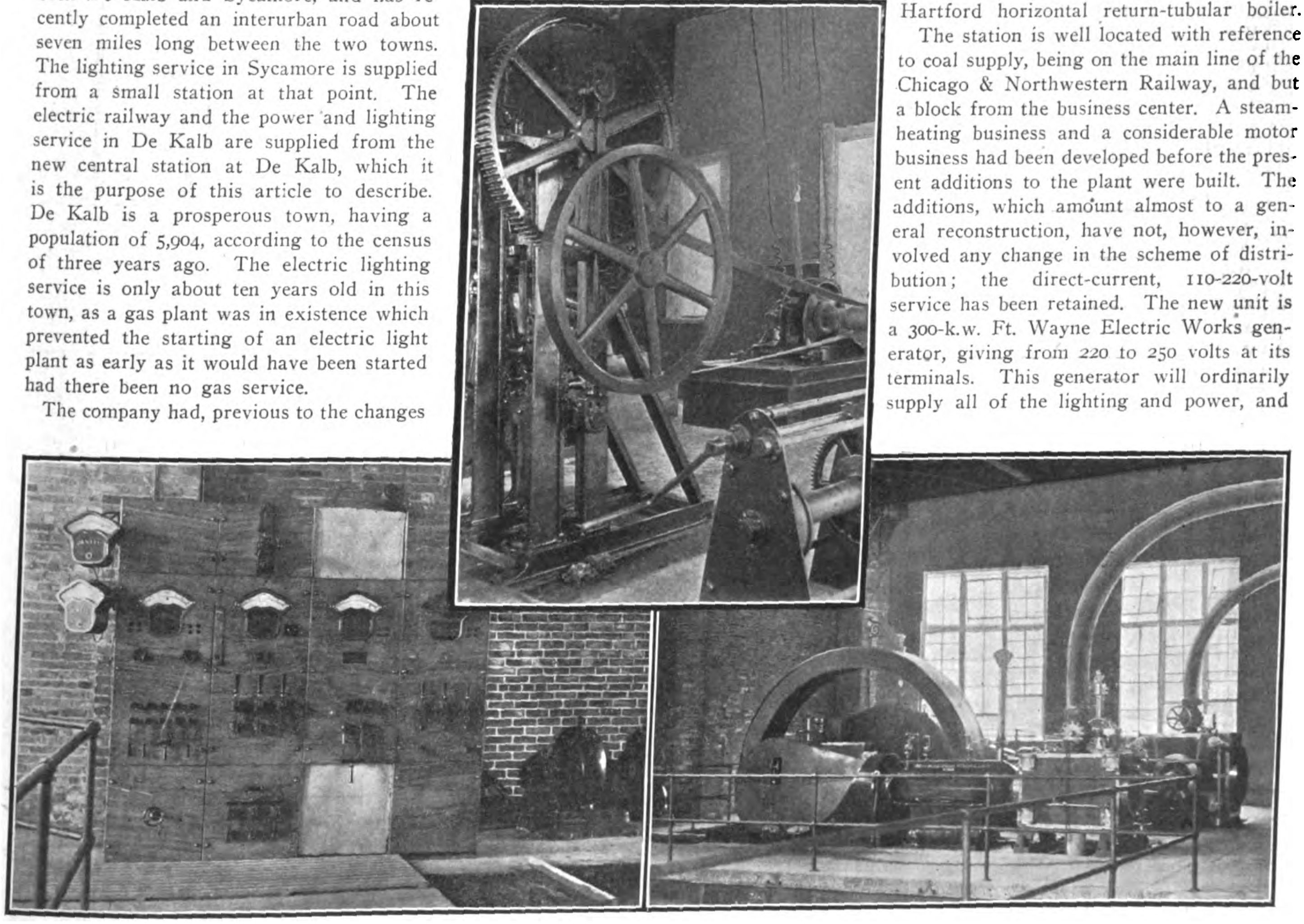
BY J. R. CRAVATH.

The De Kalb-Sycamore Electric Company has recently made improvements in its central station at De Kalb, Ill., which make it one of the most efficiently equipped small stations to be found in the middle West. The company owns the central stations at both De Kalb and Sycamore, and has recently completed an interurban road about seven miles long between the two towns. The lighting service in Sycamore is supplied from a small station at that point. The electric railway and the power and lighting service in De Kalb are supplied from the new central station at De Kalb, which it is the purpose of this article to describe. De Kalb is a prosperous town, having a population of 5,904, according to the census of three years ago. The electric lighting service is only about ten years old in this town, as a gas plant was in existence which prevented the starting of an electric light plant as early as it would have been started had there been no gas service.

The company had, previous to the changes now being made, an electric light and power and steam heating station, which was far from being as obsolete as are many of the smaller electric light and power properties in towns of this size. When the electric road was built between De Kalb and Sycamore, by this company, and the scope of the company's operations thus enlarged, the company, upon the recommendation of the consulting engineers, decided to remodel completely the central station on a larger scale than anything before attempted. The consulting engineers for this work were those of the Arnold Electric Power Station Company, of Chicago.

This station has always given but one class of service, mainly direct-current, three-wire, 110-220-volt incandescent lighting and power service. The old part of the station was first equipped with high-speed compound engines, belted to 110-volt dynamos in pairs, and the most recent unit installed was a direct-current, medium-speed vertical engine. One of these high-speed units is a 5-in. and 9-in. x 9-inch Westinghouse compound engine, belted to two 25-k.w. generators, and the other belted unit is a tandem compound Ball & Wood 9-in. and 17-in. x 12-inch engine, driving two 40-k.w. generators. The direct-connected unit is a Lake Erie 7¾-in. and 7-in. x 14-in. stroke vertical marine type engine, with a 50-k.w. generator on each end of its shaft. The boiler-room at present has two Babcock & Wilcox 180-h.p. water tube boilers, and one Hartford horizontal return-tubular boiler.

The station is well located with reference to coal supply, being on the main line of the Chicago & Northwestern Railway, and but a block from the business center. A steam-heating business and a considerable motor business had been developed before the present additions to the plant were built. The additions, which amount almost to a general reconstruction, have not, however, involved any change in the scheme of distribution; the direct-current, 110-220-volt service has been retained. The new unit is a 300-k.w. Ft. Wayne Electric Works generator, giving from 220 to 250 volts at its terminals. This generator will ordinarily supply all of the lighting and power, and will also drive a motor generator set of 100 kilowatts capacity of the same make for supplying current to the interurban road. As will be seen from the general plans of the station shown herewith, the new 300-k.w. unit has been placed in a new building adjoining the old station, and in this build-



FIGS. 1, 2 AND 3.—DEEP-WELL PUMP, SWITCHBOARD, AND CORNER OF ENGINE-ROOM.

ing space has been provided for another similar unit to be installed some time in the future.

For the present, the old station will be kept as it stands, and the boilers will supply the new generating unit. The engines and generators in the old station will serve to carry the load in case of emergency, until such time as a second unit may be put into the new building. When that time arrives, it is the plan to remove the engines and generators from the old station, and change the location of the boilers so that they will be at right angles to their present location, as shown in the small plan giving both the present and future arrangement. This will place them in a row parallel with the engine-room, and if the plant grows to sufficient size to warrant coal and ash-conveying apparatus it can be put in. The proposed arrangement for the future is such that the power house can be extended southward on a uniform scheme. The possibility that this station might some time be in a position to furnish power to a considerable mileage of interurban electric railway made it advisable to arrange the plant so as to provide for its expansion on a large scale. When the boiler-room change is made the old building will be reconstructed to bring the housing of the boilers up to the same standard of construction as the engine-room.

It will be noticed on the main plan that the motor-generator set for supplying the railway current is placed in line with the fly-wheel of the 300-k.w. unit. The fly-wheel has a 25-in. face, so that in case of an accident to the generator the motor-generator set could be driven by a belt from the engine fly-wheel, and thus not only give 500-volt current for railway purposes, but assist in carrying the 220-volt power and lighting load. To maintain the balance between the two sides of the three-wire net work, a 10-k.w. balancing set has been put in. This balancing set consists simply of two 110-volt motors coupled together, and one connected on each side of the three-wire system.

The engine is a Hamilton-Corliss cross-compound, with cylinders 18 and 28 inches in diameter by 36-in. stroke, and it runs at 120 r.p.m. The fly-wheel is unusually heavy for an engine of this size, weighing about 40,000 pounds. This is, of course, a desirable feature when lighting and power service is to be supplied from the same engine and generator, because fluctuations of the rail-

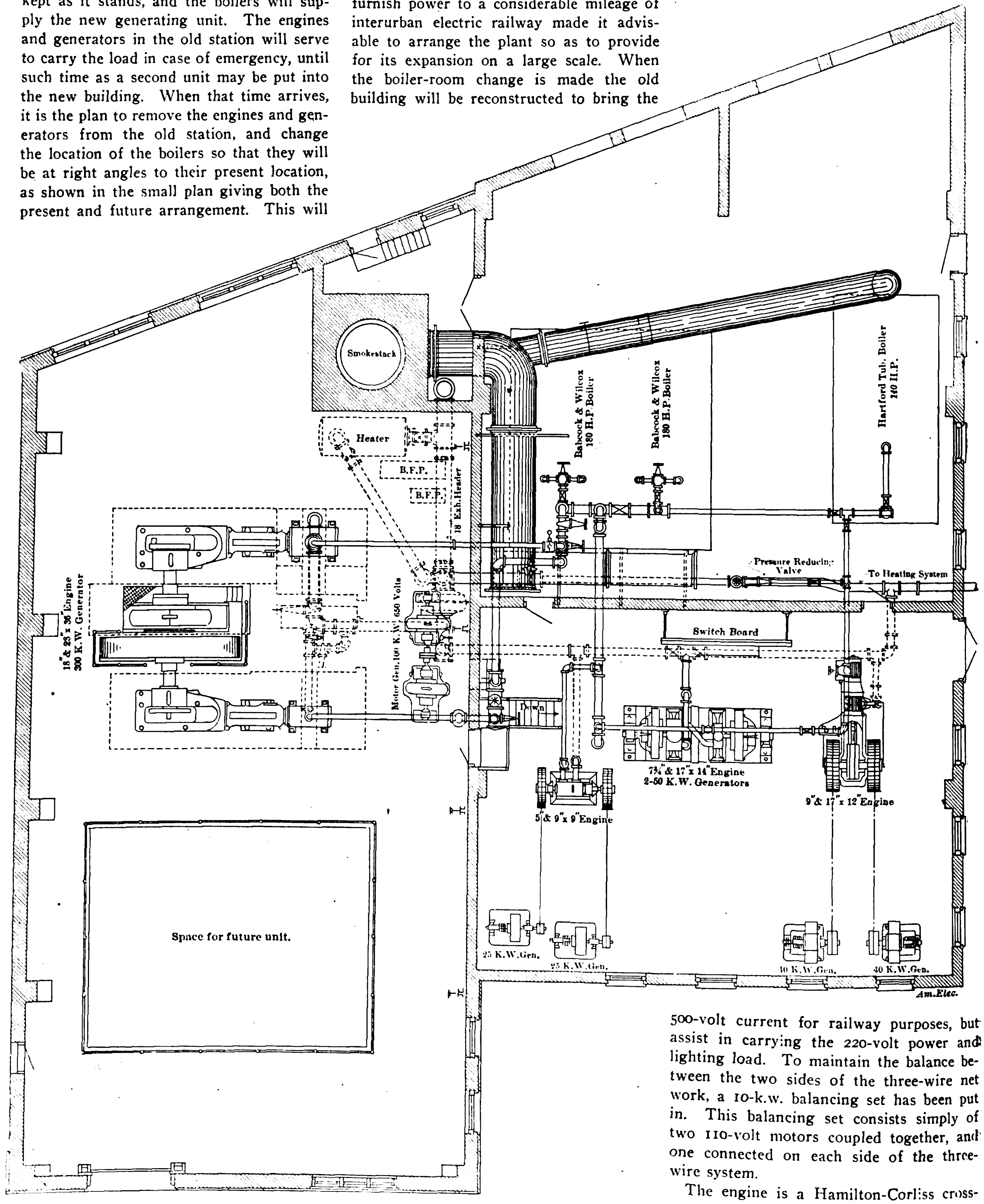

Smokestack
Heater
B.F.P.
B.F.P.
18 Exh.Header
Babcock & Wilcox 180 H.P. Boiler
Babcock & Wilcox 180 H.P. Boiler
Hartford Tub. Boiler 140 H.P.
Pressure Reducing Valve
To Heating System
Switch Board
18"& 28"x 36"Engine 300 K.W. Generator
Motor Gen. 100 K.W. 650 Volts
Down
7¼"& 17"x 14"Engine 2-50 K.W. Generators
9"& 17"x 12"Engine
5"& 9"x 9"Engine
Space for future unit.
25 K.W.Gen.
25 K.W.Gen.
10 K.W.Gen.
40 K.W.Gen.
Am.Elec.

FIG. 4.—PLAN VIEW OF DE KALB CENTRAL STATION.

way load will have less effect on the engine speed, and consequent regulation of voltage on the generator, than if a light fly-wheel were used. As regards this matter of regulation, it may be noted here that the lighting feeders are separate from the 220-volt feeders supplying the largest stationary motors. The fluctuations due to the starting and stopping of stationary motors are therefore eliminated as far as the drop in feeders is concerned.

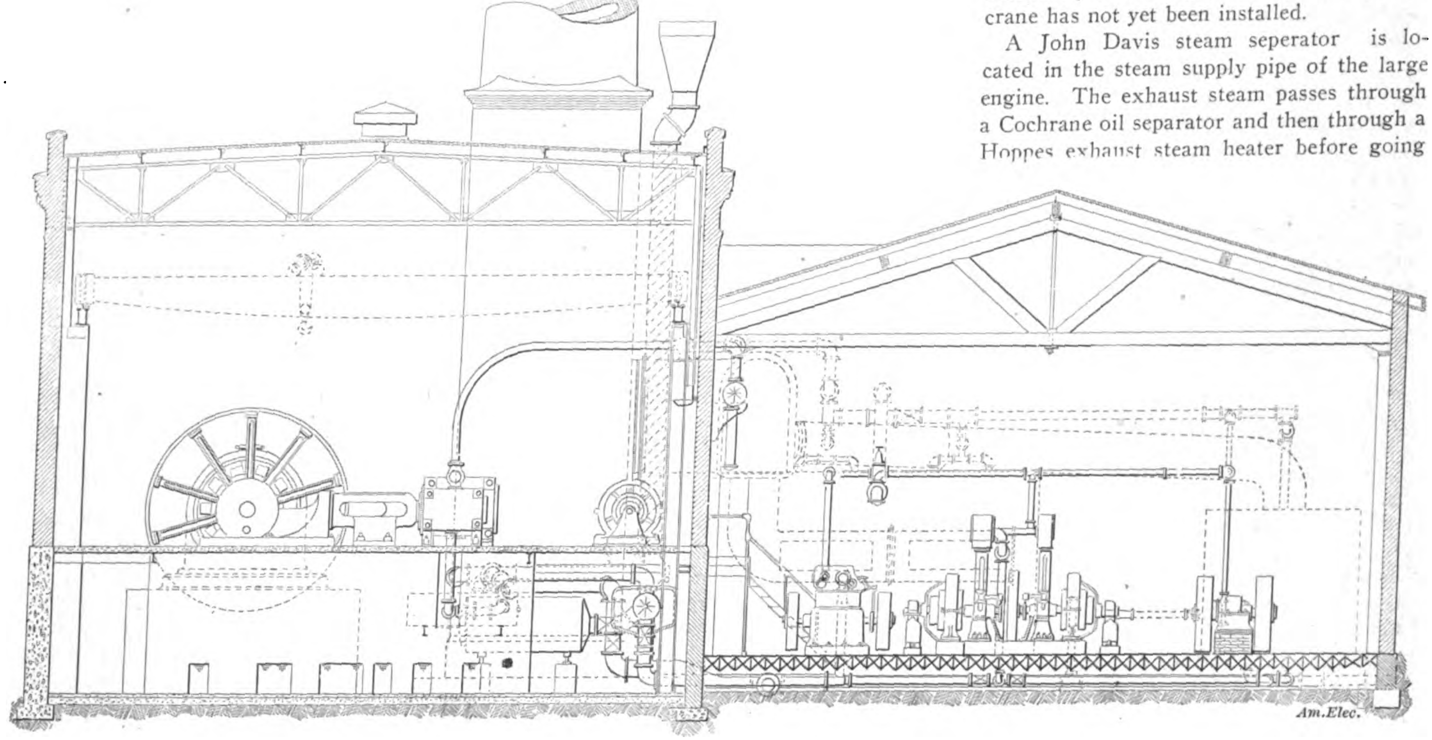


FIG. 5.—SECTIONAL ELEVATION OF POWER-HOUSE.

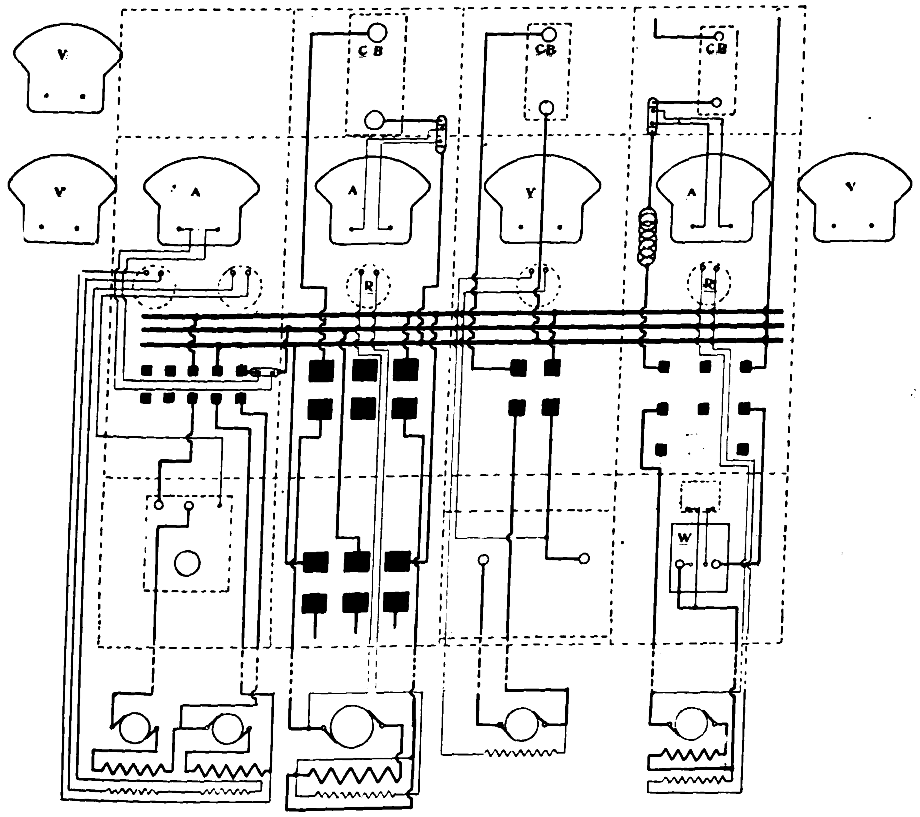


FIG. 6.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

The switchboard was built by the Western Electric Company, and is equipped with Jewell station ammeters and volt-meters. It is laid out for one balancing set panel, one main generator panel, one railway motor-generator control panel, and one output panel for the railway motor-generator. A Cutler-Hammer multiple switch for starting the motor-generator is to be put in one of the blank panels shown by the accompanying illustrations. Western Electric circuit-breakers are to be put in the top section of the generator panel and the two motor-generator panels. The switchboard connections are shown in Fig. 6.

Provision has been made in the new building for a traveling crane to handle heavy machinery in the engine-room, although this crane has not yet been installed.

A John Davis steam seperator is located in the steam supply pipe of the large engine. The exhaust steam passes through a Cochrane oil separator and then through a Hoppes exhaust steam heater before going to the steam heating mains. The pressure on the exhaust steam heating system is never more than 3 lbs. per square inch. The Paul vacuum system consisting of vacuum pipes running to the air valve of each radiator is used. The heating system has 18,632 square feet of radiating surface connected; the piping of the system is that of the American District Steam Company. The mains extend to a maximum distance of 750 feet from the station.

In addition to the boiler and engine-rooms, the power house building has elaborately arranged and equipped exhibition, repair and office rooms, together with lounging and locker rooms for the employees. The exhibition offices and employees' rooms are fitted up in antique oak and furnished as handsomely as the offices of any electric light company in the country. The entrance room, as marked on the plans, is the one open to the public, and here one finds a handsome display of shades, electroliers, heating devices, fans and all electric appliances for sale by the company. This is a feature which is too often omitted in the offices of central station companies in towns of this size.

The supply and store-room is well fitted up with labelled boxes for the storage of all small apparatus and parts, and racks for storage of the different sizes and voltages of incandescent lamps. The engine-room and display-room are separated by an open partition and sliding doors. In the employees' lounging-room, a handsome reading table and oak chairs are provided, and copies of recent technical publications are kept on file. Behind the lounging-room is a locker-room and also a shower bath.

This station was one of the pioneers in

furnishing current for electrically-driven city water-works pumps. The De Kalb water-works system is supplied entirely by motor-driven pumps operated on the 220-volt mains of the station, and no steam apparatus whatever is installed at the water-works pumping station: this station is 2,200 feet from the electric station. Water is taken from deep wells by two Downie double-acting deep-well pumps, one driven by a 25-h.p. motor and the other by a 15-h.p. motor. These pumps have 8-in. plungers and are 18-in. stroke. There is also one Goulds deep-well pump, with a 6¾-in. plunger and an 18-in. stroke, driven by a 7-h.p. motor. All of these pumps run at 20 r.p.m. It will be noted in the illustration of one of the Downie deep-well pumps that a rather heavy fly-wheel is provided; this, together with the double action effect of the pump, so reduces the fluctuations on the motor that the current varies only about 10 per cent between different parts of the stroke. These double-acting pumps have two plunger rods, one inside the other. Inasmuch as considerable trouble has in some cases been experienced with deep-well pumps, owing to the frequency with which the rods and plungers must be taken out for repairs, it is interesting to note that these pumps have given very little trouble, sometimes running as long as a year without being hauled out for repacking or other repairs. The building over the pumps has towers over each well, and a hand windlass, shown in the foreground of Fig. 1 is used in hauling up the rods and plungers of the pumps. The towers above the pumps are of course for the purpose of permitting the rods to be taken out without opening a hole in the roof. These deep-well pumps simply lift water from the wells to reservoirs at the surface; this lift is about 147 feet. For raising the water from the reservoirs against the standpipe head, which is 163 feet, there are two triplex Goulds pumps, each of which is driven by a 50-h.p. electric motor through gears. These pumps have 10-in. cylinders with a 12-inch stroke.

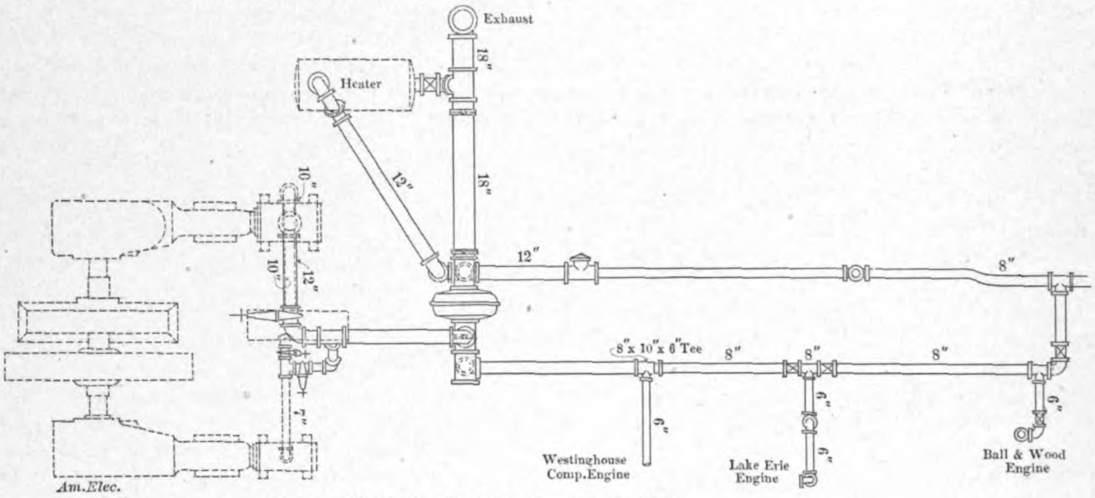


FIG. 7.—DIAGRAM OF LOW-PRESSURE PIPING.

A man visits this plant twice a day. The stopping and starting of the motors is done at the central station by means of hand rheostats. All three of the deep-well pump motors are started by a single hand rheostat, and the motors driving the triplex pumps are independently started, but a common-return wire is used for these two motors. It has been found desirable, however, in addition to the rheostats at the power house, to have an individual rheostat at the pumping station for each motor, so that every motor can be started for testing purposes by anyone at the pump-house, independent of the other motors. The city owns all pumping machinery, but the central station company takes care of the apparatus and provides all ordinary maintenance. The water pumped is measured by a Venturi meter, and about 250,000 gallons of water are pumped per day. The rate received for pumping is 4 cents per 1,000 gallons, which includes the entire lift from the bottom of the deep well to the standpipe—a total lift of 310 feet. It has been found that this rate amounts to about 3 cents per kilowatt hour, which figures up 1,333 gallons per kilowatt hour.

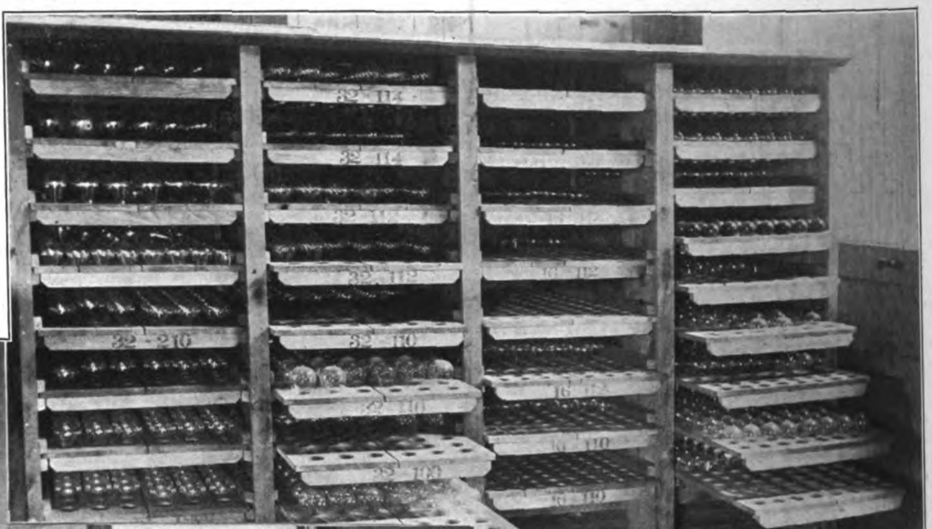


FIG. 8.—LAMP-STORING TRAYS.

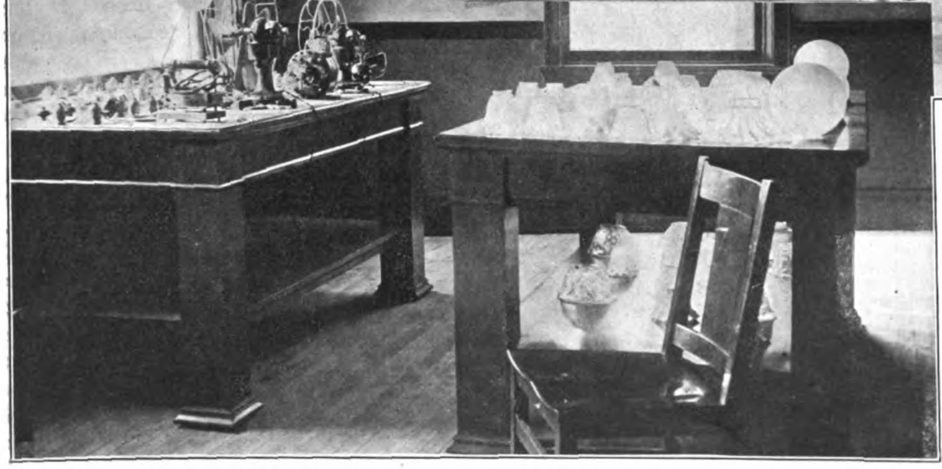


FIG. 9.—VIEW IN THE DISPLAY ROOM.

Light and power service is sold by meter. For lighting, the bills each month are made out so as to charge a customer at the rate of 20 cents per kilowatt hour for current consumed up to the point where the current consumed is equivalent to the use of each connected lamp one hour per day. The remainder of the energy consumed is billed at 6 cents per kilowatt hour. The portion billed at 20 cents per kilowatt hour is subject to 25 per cent discount for payment before a certain date. The balance of the bill is net at 6 cents. The rates for power are arranged so that a customer must pay a minimum of $1.00 per month per horse-power installed, plus a rate of 3 cents per kilowatt hour for the energy supplied, or if the customer prefers, he can obtain a straight rate of 6 cents per kilowatt hour without the minimum charge. The large customers get a rate of 3 cents per kilowatt hour. The station has connected up over 400 horse-power in motors, which range from ¼ horse-power up. Five of these motors are in the water-works and nine in the works of the De Kalb Fence Company. It is evident that the company is competing with individual steam plants of considerable size when it secures such large customers. The wattmeters are Thompson instruments, and are tested on the customer's premises at least once a year with a voltmeter and an ammeter. The heating rate is 25 cents per sq. ft. of radiating surface per year. Coal for the coming year will cost the company $2.50 per ton; the coal used is Spring Valley (Illinois).

Mention has been made before of the attention given to the appearance of the offices and the store-room, and in fact all the company's property. This costs practically nothing, and is worth considerable to the company, in the respect it demands from the public, who may have occasion to visit the plant. Employees take turns in seeing that the store-room and offices are kept neat. The name of the employee who is caretaker for the week is posted in a conspicuous place in the repair shop. Having the employee responsible for the appearance of things gives much better results, of course, than having it everybody's business, which is nobody's business. The station is under the charge of John Glidden, superintendent of the De Kalb-Sycamore Electric Company, who is largely responsible for the satisfactory condition of the company's business and property at the present time.

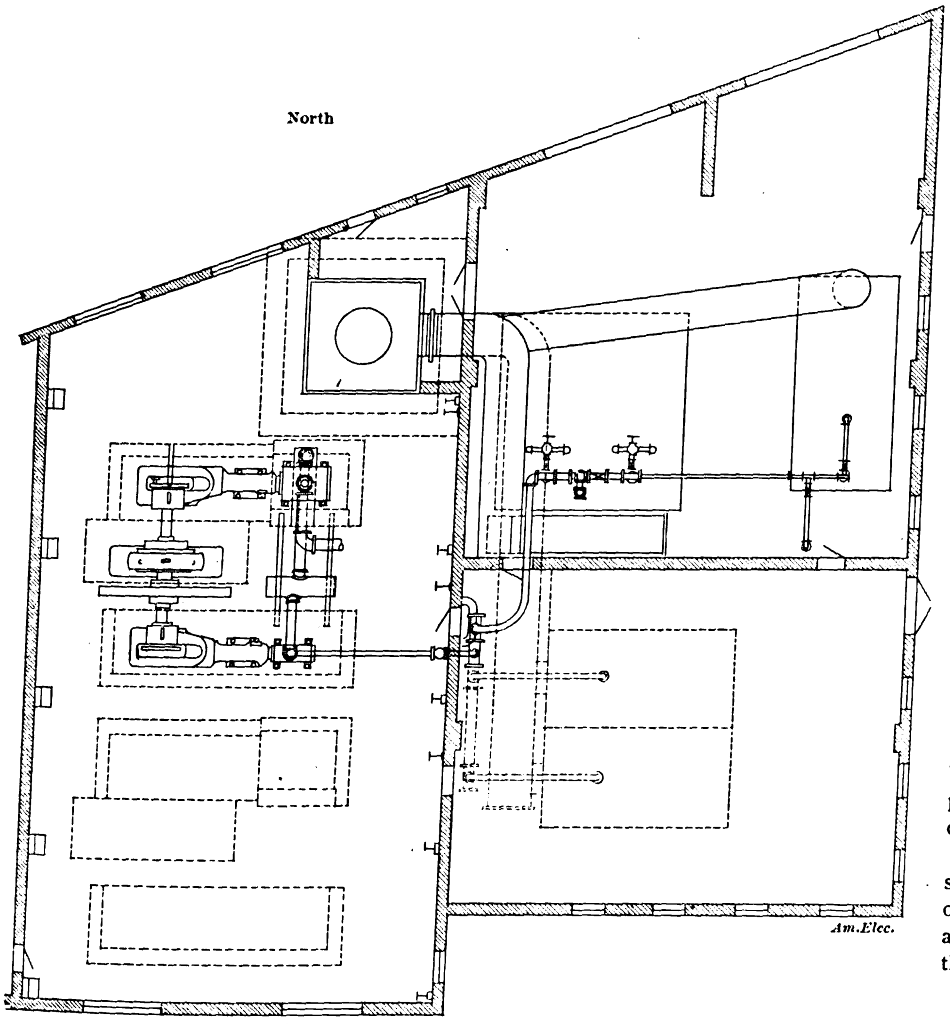


FIG. 10.—ARRANGEMENT OF BOILERS, SHOWING PLAN FOR FUTURE EXTENSION.

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STEAM TURBINE EFFICIENCY.

BY W. T. EDWARDS.

The most notable steam-turbine installation in this country is the oft-described machine at the station of the Hartford Electric Light Company, Hartford, Conn. This turbine has a rating of 1,500 kilowatts, but it carries a load of 2,000 kilowatts with no indication of distress, and with little loss of efficiency. An installation at present being prepared that will be of much interest is the one for the Rapid Transit Subway Construction Company, to be used for lighting the forty-seven underground stations and the power station at Fifty-ninth Street. The plant will comprise three 1,250-k.w. Westinghouse turbines direct-connected to three phase generators.

The efficiency of the steam turbine seems to vary but little with large variations of load, and the size of the unit seems to have but little effect on the result. Tests show a steam consumption varying from 14.47 pounds of steam at full rating to 16 pounds at half-rating, and to less than 19 pounds at one-quarter capacity. One test, with boiler pressure at 153 pounds, vacuum 26.94 inches, superheat 20° Fahr., 3,630 revolutions per minute, showed a total water consumption of 8,789 pounds, and an output of 607 brake horse-power; the water per horse-power being therefore 14.47 pounds.

An important indication of tests thus far made is that moderate-sized plants may be so arranged and sub-divided as to give great flexibility of service and still have an efficiency that is possible only in large reciprocating units. And a variable load may be cared for with a high degree of economy. When larger units are considered the turbine is then comparable with the best steam engine practice. Here it holds its own and continues to show a uniform efficiency. A test is cited in which the result of 11.7 pounds of steam per electrical horse-power-hour was guaranteed, which is about equivalent to 10.7 pounds per indicated horse-power. Comparisons made at Hartford, of the relative efficiency of the turbine and the Corliss engines there showed that the turbine could deliver at the switchboard 1,900 kilowatts for about the same amount of coal that was required by the engines to deliver 925 kilowatts, the steam pressure and vacuum being the same in both cases. This test was made under operating conditions, and was continued for an extended period. Another test, at Wilmerding, of a 400-k.w. turbine-generator gave a result of 16.4 pounds of steam per electrical horse-power-hour, with 125 pounds steam pressure and 26 to 27 inches of vacuum; at one-half load the steam rate was 18.2 pounds. The use of superheated steam in turbines is, of course, practicable at almost any rational temperature; as the turbine requires no internal lubrication, the water of condensation is pure, and where the cost of boiler feed water is an item to be considered this becomes quite an important factor, since the condensed exhaust can be returned to the boilers.

What will develop from further tests of steam turbines, and whether the installation of large units is wise practice or not, time alone will tell, and we are all waiting for the results.

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Causes of Trouble in Central Stations.—W. G. Carlton, assistant to the chief operating engineer of the Chicago Edison Company, at the Chicago meeting of the A. I. E. E. on May 5, when the tendencies of central station development were being discussed, said that three-fourths of the troubles in his company's plants had been mechanical; where electrical troubles had occured they had been mainly in the station, so that the troubles outside the station were very much in the minority. His company divided the load among independent feeders as far as possible, especially in the high tension work.

Steam Practice in American Electric Light and Power Plants

By Geo. H. Barrus, Geo. I. Rockwood, H. C. Meyer, Jr., and Chas. W. Oliver.

SOME POINTS REGARDING BOILER PRACTICE IN ELECTRIC LIGHT AND POWER STATIONS.

BY GEORGE H. BARRUS.

Readers of the AMERICAN ELECTRICIAN are doubtless familiar with the general construction of all the modern types of water-tube or sectional boilers, and a detailed description of them is therefore unnecessary. It may be of interest, however, to present the salient features of a number of the leading types before taking up the more general subject.

Fig. 1 represents the well-known Babcock & Wilcox boiler, among the attractive features of which are its durability and what is closely allied to it, the facility with which it can be repaired. The parts which are subject to the most wear, and consequently require the most frequent repair, are the tubes, and the repair of a tube in most cases is simply a question of its renewal. To renew a tube in this boiler is an easy task. First, the cap at each end is removed by unscrewing the nut which holds it, and then the old tube is cut away and pulled out. The new tube is inserted by slipping it lengthwise through the opening in the front header until it reaches its place, and finally the ends are expanded and the tube thereby secured. By renewing the tubes whenever required, the boiler may be kept in use for many years. Strength and stability are also features in the design and construction, and no doubt the security furnished by suspending the entire boiler from overhead girders resting on outside columns contributes much to its durability.

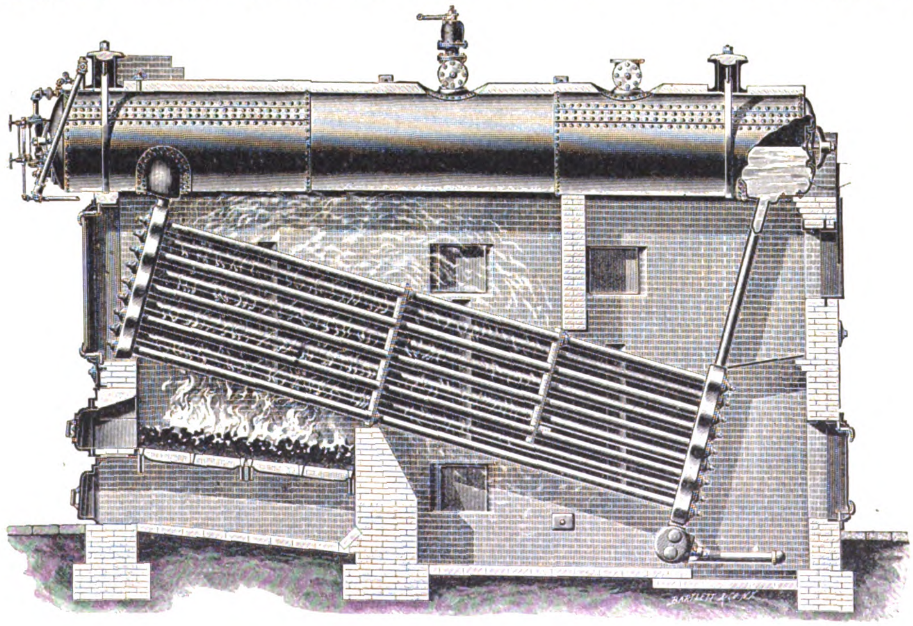

FIG. 1.—BABCOCK & WILCOX WATER-TUBE BOILER.

Another advantage lies in the facilities afforded for thorough examination and cleaning. The boiler is divided crosswise into three compartments, to each of which there is ready access for the inspection of the exterior surfaces of the tubes, and to some extent for cleaning them. Side openings through the walls allow the easy use of the steam hose for blowing off soot and ash, as is done in the regular practice of cleaning. Caps at the end of each tube permit the thorough inspection of the interior from end to end, and at the same time allow the introduction and use of the scraper or tube cleaner, which is required when scale collects on the inside surfaces to such an extent as to be objectionable.

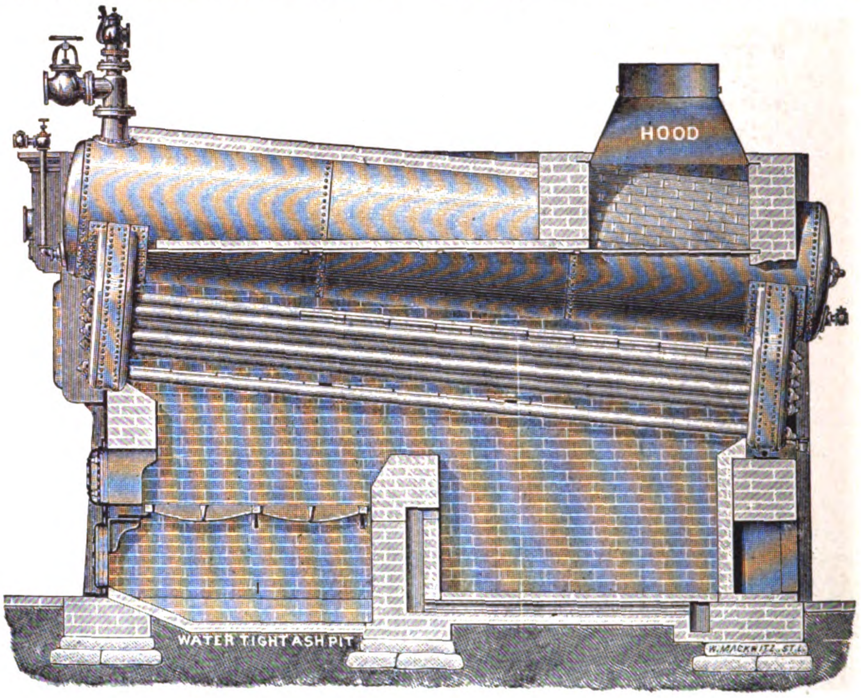

FIG. 2.—HEINE WATER-TUBE BOILER.

An attractive feature in this type of boiler is the large amount of power obtainable in a single unit. By employing the double-deck arrangement of tubes and increasing the number of sections and the corresponding width of grate surface, any desired amount of power, within practical limitations, can be had in one unit. Many of these boilers have been used satisfactorily in which the length of grate is 7 ft. and the width 12½ ft., which, with medium draft, represents some 500 rated horsepower; and even larger sizes have been employed. In this connection, a very important advantage may be mentioned, that the boiler can be worked far beyond its rated power without other detriment than that which naturally follows overwork, and nowhere is this matter of greater moment than in electric light and power plants. With medium draft and good coal, this excess of power is frequently 50 per cent of the rating, and, under forced conditions, it may go much higher.

These boilers are favorites because they provide ample area of steam disengaging surface, and consequently a large reserve of water capacity above the fire surface. In the daily care of boilers where this feature does not exist, the closest attention is required from the water tender to prevent the danger arising from low water and likewise the trouble produced by high water.

The use of boilers adapted to moderately high pressures is almost a necessity in the present day of multiple-expansion engines, and the boiler in question possesses all the attractive features required for this class of service. The common practice to-day is the regular use of pressures running from 150 to 175 pounds, and the tendency is constantly upward. If the shells and heads of the drums are made of best quality steel plate, with double strap butt joints at the longitudinal seams; and if the headers and saddles or cross-boxes attached to the drums, are made of suitable forged or cast steel, the pressures noted and even higher pressures are readily and satisfactorily withstood.

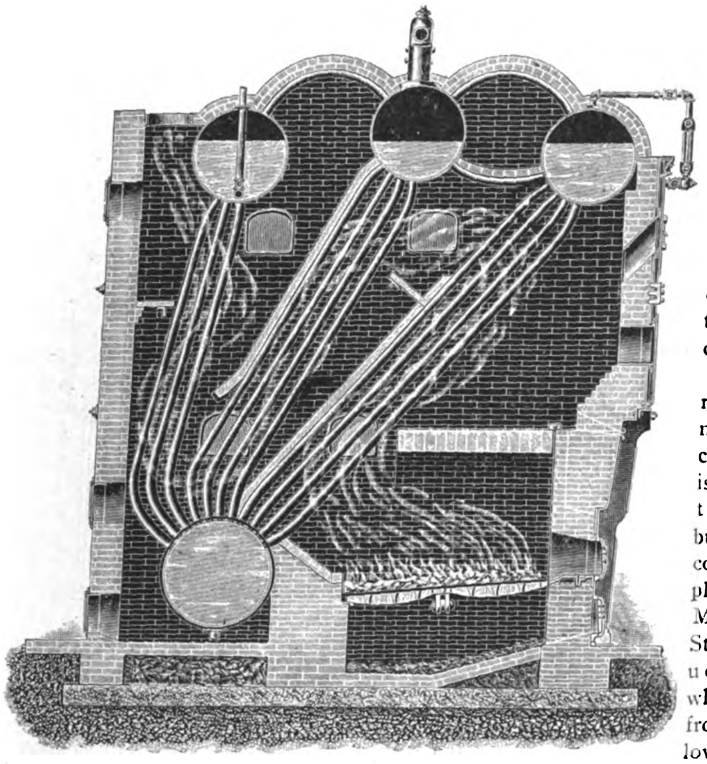

FIG. 3.—STIRLING WATER-TUBE BOILER.

These boilers produce steam which is commercially dry even when forced a high degree beyond their rated capacity. In cases where specially dry steam or highly superheated steam is required, the construction of the boiler is such that superheating tubes may be readily introduced.

Another boiler of the horizontal water-tube class which has become prominent in the practice of electric light and power stations is the Heine boiler, shown in Fig. 2. This boiler has a number of distinctive features which specially commend it to steam users. It occupies a minimum amount of floor space. Any desired number of units can be set in one battery of brickwork, with a single intermediate wall between each boiler and the next, without the necessity of making provision for passage ways. The special reason that makes this practicable is that no openings are required through the side walls, either for the purpose of entrance or cleaning. Access to the space beneath the tubes is had through the furnace doors, and to the space between the tubes and the drum through doors at the top. Special provisions are made for cleaning the tubes.

The method provided for blowing off soot and ash from the outside surfaces of the tubes is an attractive feature and one which is most effective for the purpose. Hollow stay-bolts pass through the water leg at each end of the boiler, these being placed centrally in the open spaces between the various nests of tubes. A small steam pipe is introduced either from the front or rear as may be desired, and the steam which is turned into the pipe escapes in a jet from the open end. This jet blows along the entire length of the four surrounding tubes and covers a quarter of the circumference of each. The result is that after the whole boiler has been gone over, the entire circumference and length of all the tubes has come within its range. Everyone realizes, in a measure, the importance of clean heating surfaces in a boiler, but it is doubtful if many give the subject the attention it deserves, even when the best facilities are provided, as they are here, for securing the object.

The design and arrangement of the furnace and combustion chamber in this boiler is one that is adapted to the advantageous burning of volatile coals, such, for example, as are found in the Middle and Western States. When the products of combustion which are first distilled from these coals are allowed to cool too rapidly, as they do when prematurely brought into contact with the heating surface, imperfect combustion and consequent loss of economy is the inevitable result. In the arrangement provided in this boiler, the products of combustion, after leaving the grate, travel the whole length of the boiler before reaching any considerable amount of tube surface. Undue fall in temperature is thus delayed, and there is time given for the gases to become more thoroughly mixed and ignited than would otherwise occur.

The vertical type of water-tube boiler is also extensively used in electric work. It goes without saying that a boiler in which the heating surface consists mainly of vertical tubes occupies less ground area than one of the horizontal type, and this is one of the decided advantages which vertical water-tube boilers as a class possess. One of these boilers, which is widely used, is the Stirling boiler, shown in Fig. 3. The Stirling boiler has the following characteristics which give it special merit and popularity:

Its design and construction adapt it to situations where the feed-water contains impurities, whether these are held in chemical solution or in mechanical suspension. In the natural operation of a boiler, the impurities are separated from the water and thrown down upon the heating surfaces, where they form a covering of scale. The scale retards the transmission of heat, and causes not only loss of economy, but it endangers the life of the metal through the tendency to overheat. This trouble becomes more and more serious as the thickness of the scale increases, and in localities where the feed-water is very bad, it is the source of almost endless annoyance and expense. In the Stirling boiler, the water is first supplied to the rear steam drum and the rear bank of tubes where it comes in contact with the gases which are leaving the boiler, and it then passes down into the mud drum. The water is thus heated at the outset to its maximum temperature, and this is the condition required for the precipitation of most of the impurities that form scale. On entering the mud drum the water emerges into a comparatively large open space, and it becomes a slowly moving current, which furnishes an opportunity for the impurities which are now largely in suspension to settle and collect in the bottom of the drum. Here they are in a position to be readily blown out, and do no further harm. The water, after being thus purified, circulates up and down through the front and middle banks of tubes where most of the steam generation takes place, and few impurities remain to be deposited in this part of the boiler. In practical operation, comparatively little scale is found in the two front banks of tubes, while that deposited in the rear bank is comparatively soft and easily removed, being exposed to the low temperature of the escaping gases. The interior of this boiler is arranged to be most accessible, whether for the simple purpose of examination or for cleaning. The removal of four manhole plates furnishes entrance to the four drums and exposes to view the ends of all the tubes in the boiler.

Among the vertical water-tube boilers the Cahall boiler, shown in Fig. 4, although of comparatively recent introduction, is one which has met with favor. This boiler is notable for its simplicity of design and construction. It consists merely of two drums connected together by a nest of straight tubes. Being of this simple design it is easily examined both inside and outside, and, for the same reason, the surfaces are

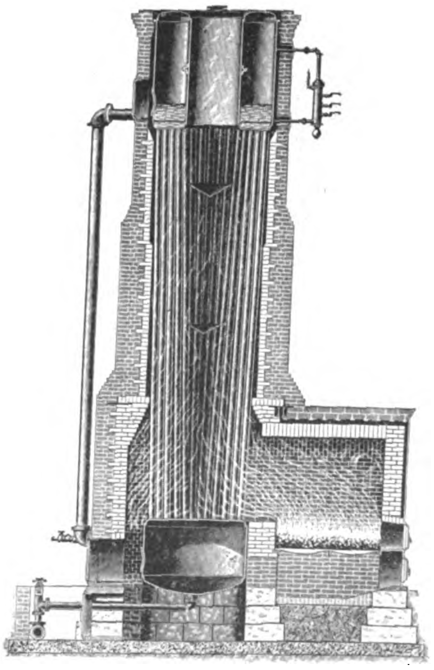

FIG. 4.—CAHALL WATER-TUBE BOILER.

readily cleaned and kept in repair. One of the features of the boiler is the design of the furnace, which is an external chamber entirely surrounded with brickwork, excepting at the end nearest the boiler. In practical operation it is found that this arrangement is favorable to a high degree of furnace efficiency and excellent combustion.

Two other water-tube boilers of the vertical class (but provided with horizontal tubes) have obtained distinction. These are the Hazelton boiler, shown in Fig. 5, and the Climax boiler, shown in Fig. 6. The former possesses the merit of simplicity and easy repair, consisting, as it does, of a single vertical drum, from which radiate a large number of short horizontal tubes which are expanded into the shell. In both of these boilers the grates are circular, and the boiler occupies no more floor space than the furnace itself. A slight increase in the diameter adds much to the area of the grate surface, and for this reason a large amount of power can be obtained from a single unit, without employing grates of unweildy length.

In giving prominence to the boilers here illustrated as representing the leading practice in electric power stations, it has been the intention to record the fact of their extended use and the characteristics which have made them favorites, without entering into a discussion of their relative merits. The fact of their wide adoption is an indication of merit, which is sufficient for all practical purposes. Besides those mentioned, there are many other water-tube boilers that are in successful operation, though in narrower fields, and a great number of fire-tube boilers, both horizontal and vertical, which are used largely in the smaller stations. It is hardly within the province of this article to make so complete an exposition of the subject as to refer specially to all these types.

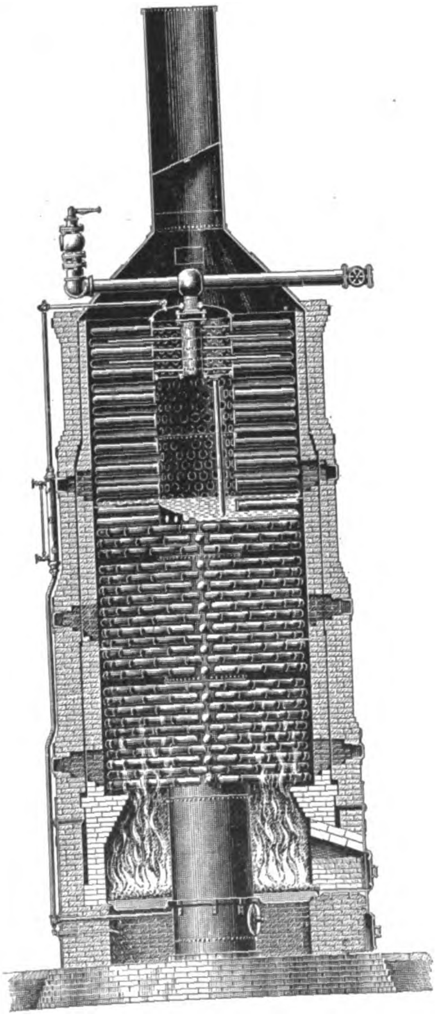

FIG. 5.—HAZELTON WATER-TUBE BOILER.

Passing now to questions of boiler performance in power stations, and matters of design, proportion and operation relating to the subject, we find much for consideration. These are questions which may be taken up without reference to any special forms of boilers, for in most cases they apply to one as well as to another. They may be considered under various heads as follows:

Heating and Grate Surface.

It is common practice in designing boilers for electric work, especially those of the water-tube class, to provide 10 sq. ft. of heating surface for each boiler horsepower required, and a common proportion of heating surface to grate surface which is employed is 50 to 1, although less is often provided. To develop a boiler horsepower, which represents 34.5 pounds of water evaporated per hour from and at 212° Fahr., it is necessary, therefore, for each square foot of surface to evaporate 3.45 pounds of water per hour. With the best conditions regarding the quality of coal and method of hand firing, the evaporative efficiency reaches 11.5 pounds of water, from and at 212° per pound of coal. Using this evaporation a boiler having 10 sq. ft. of surface per horsepower and the above ratio of 50, works up to its rated power when the consumption of coal is 15 lbs. per hour for each square foot of grate surface. With a poorer grade of fuel and less efficient firing the rate is increased accordingly. For example, when the coal is one containing a high percentage of volatile matter, such as many coals have which are mined in the West, and no special provision is made for obtaining high furnace efficiency, the evaporation may be as low as 6.9 lbs., and the rate of combustion rises to 25 lbs. per sq. ft. of grate per hour.

In obtaining the highest economy from a given amount of heating surface it is found important to distribute the tubes and the surfaces concerned so that the products of combustion come into contact with all parts of the surface. In fire-tube boilers this is accomplished by suitably proportioning the number of tubes to their length and area. If the tubes are of such number that the aggregate area through them is one-eighth of the grate surface, the distribution is generally considered to be effective. In water-tube boilers the proper distribution of surfaces is obtained by the use of baffle-plates. When the baffling is not arranged in the best manner, the path of the gases is shortened to the easiest course through the passages and loss of economy results. The surfaces outside of the central path thus become ineffective. In the best practice with these boilers, the area through the passages is baffled down to the least amount consistent with securing the necessary draft to work the fires to advantage.

The economy obtained from a given amount of surface is found to be more or less dependent not only on the distribution of the surface, but also on the location of the surfaces with respect to the furnace, especially with volatile coals. In hand-fired furnaces, the surfaces must not be so near the furnace that the gases first distilled from the coal are cooled below the temperature of ignition. The gases must also be given time to mingle with the air for combustion before becoming too much cooled. The best results are secured in boilers where these matters can be most effectively provided for, and in such cases, it is found that a minimum extent of heating surface suffices to produce a given rated horse-power.

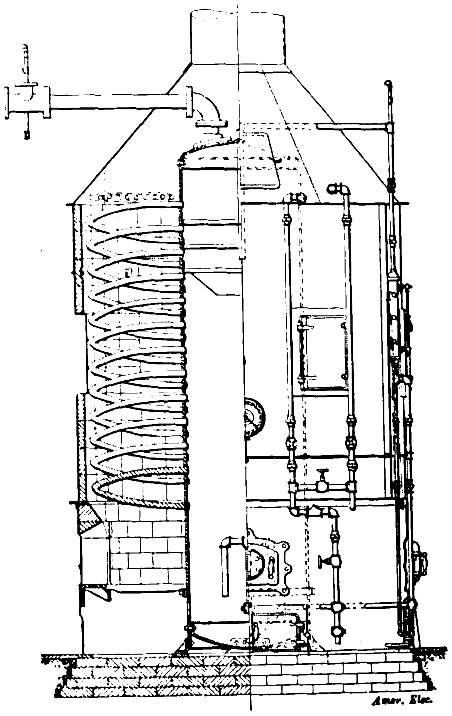

FIG. 6.—CLIMAX WATER-TUBE BOILER.

What the best ratio is between heating and grate surface depends somewhat upon the rate of combustion on the grate. When the surfaces are properly baffled so as to make them thoroughly effective at all points a higher ratio is profitably employed as the rate of combustion increases, although this cannot be carried to extremes without unusual care in firing. The proportion and rates given above have been found to answer most of the requirements met in ordinary good practice with semi-bituminous coal. Where anthracite coals of the small sizes are burned, a much larger area of grate surface is required in a boiler of given size and the proportion between the heating and grate surface reduced, although in many cases this is effected by employing a forced blast in the ash pit.

To secure easy steaming without excessive draft, the area of openings through the grates requires to be large in proportion to the entire surface. It is common practice to use grates having 50 per cent air space, and with this area satisfactory results are produced both as regards economy and capacity. If mere economy is desired without regard to capacity, it has frequently been found desirable to reduce the area to one-third of the grate surface.

Boilers are frequently run in regular work, and made to develop much more than their rated power, the idea being that it is an economical practice. In some situations no doubt this practice is advantageous, but in the large majority of cases it is usually held that, all things considered, taking into account the wear and tear which rapidly increases, it does not pay to go much beyond the rating of the boiler, excepting in emergencies. In the best practice it is found profitable to furnish considerable excess in the matter of capacity so as to meet all the various contingencies which arise in the practical operation of the boilers.

When the plant is of sufficient size to warrant it, at least one spare boiler is kept continually out of service and undergoing cleaning and such repairs as are from time to time found necessary.

Draft.

To burn the requisite amount of coal to work a boiler to its rated power, and at the same time to furnish a reasonable amount of excess power for contingencies, the force of draft in the smoke flue at the damper usually desired for satisfactory work is one-half inch water pressure, although under the best conditions less draft is found to answer. When there are no obstructions in the flues leading to the chimney and the whole work pertaining to this part of the boiler plant is properly laid out, a chimney 150 ft. high furnishes the necessary draft to accomplish these ends. In situations where it is the practice to carry heavy fires or where it is necessary to overload the boilers, a greater force of draft is needed and the height of the chimney increased accordingly.

With free-burning semi-bituminous coal of high calorific power, a horizontal tubular boiler has been found to develop its rated capacity with an average of less than one-quarter inch draft at the damper, and a vertical tubular boiler with an average of one-eighth inch. The actual amount of draft required in any given boiler depends on the characteristics of the coal, the thickness of the fire and the amount the fire is worked. The more free-burning the characteristics possessed by the coal, as also the thinner the bed of fire, and the more open the fire is kept by the frequent use of the stoking tools, the less the required draft. Anthracite coal requires a stronger draft than bituminous, and the smaller the sizes of coal the stronger the necessary draft.

In proportioning the flues leading to the chimney and in establishing the size of the chimney itself, the best practice calls for large areas commensurate with the sizes of the boilers to which they are connected. Where the chimney flue and its branches are of insufficient size, it is found that a rapid decrease occurs in the force of the draft, as the distance from the chimney increases. In some plants chimneys are used which are carried up to enormous heights. This is one method of providing the necessary draft for a large number of boilers. In such cases, however, it is not expected that the increased force of draft at the bottom of the chimney which is thus secured extends through the main flues to the boilers, for the chimney flue is made much smaller than the combined boiler flues and the draft at the chimney is not maintained beyond the flue connection. A chimney of medium height is quite as effective for ordinary cases, provided the interior flue is of ample size for the boilers connecting into it, and the intervening flues are of sufficient capacity.

Flue Temperature.

There is no settled practice in electric power plants as regards flue temperature as this depends largely upon the kind of firing, the care with which the boilers are cleaned, and the capacity to which they are worked, to say nothing of type of boiler. Where the heating surfaces are not adequately cleaned of soot and scale and where the boilers are continuously overworked, the flue temperature is necessarily very high, very often in excess of 600° Fahr. In cases where the boiler plant is cared for in the best manner and the boilers are worked at their rated capacity, the fuel being of good quality, the system of firing efficient, and the boiler of efficient type, the average temperature of the flues does not go much over 500°.

The effect which blowing off the soot has upon the flue temperature is by no means insignificant, and it shows that the daily cleaning which is followed in best practice is advantageous, especially when the boiler is in continuous service.

With the more volatile coals, the flue temperature is usually higher than with those which are low in volatile matter, and in both cases, higher than with anthracite coal.

Insufficient heating surface and improper baffling which makes the surfaces only partially effective are the causes of high flue temperatures when the conditions of operation are otherwise favorable.

The loss of heat due to high flue temperature in many of the larger electric plants is reduced by the employment of economizers, the heat being recovered and passed back into the boiler with the feed water. In many cases, the economizer reduces the temperature of the gases 200° or more and adds 100° or more to the temperature of the feed water.

Fuel.

It is difficult to say much about boiler practice as regards fuels used, because this matter is controlled so largely by the locality in which the boiler happens to be installed. The fuels which are most favored in localities where the price permits of their being used are the semi-bituminous coals which are mined in the States of Maryland and Virginia. These coals are comparatively low in volatile matter and ash, and they are specially adapted to economical work in hand-fired furnaces. They have the highest calorific value of any, and produce the highest evaporative performance, not only in practical work but in scientific tests. Bituminous and semi-bituminous coals are usually preferred to anthracite coals, excepting where the cost favors the latter, for the reason that with them a boiler can be worked to much higher power than it can be with slow-burning anthracite coal.

One of the best methods practiced for determining the value of any particular fuel prior to purchasing in large quantities is to have one of the boilers of the plant so arranged that the feed-water can be weighed or measured independently of that used by the remainder of the plant. The coal is then fired in this boiler and the evaporative performance determined under working conditions. By this means the cost of evaporation and all points regarding the adaptability of the fuel to the work required of it are ascertained. The test-boiler also furnishes means of determining the best method of firing any particular coal and the economical rate of capacity.

Firing.

As it is the practice in most of the large electric stations to install automatic stokers as a part of the equipment of the boiler plant, it may be held that in these cases at least, the matter of firing requires no consideration. This is a mistaken idea. There is no doubt that in many plants where mechanical stokers are used the fires receive far less attention than is required for good work. When the operation of the stoker is left too much to itself, the condition of the fires is liable to become so unsatisfactory that the advantage of the automatic apparatus for feeding, so far as effecting fuel economy is concerned, is defeated. In the best practice the fires and stokers are watched quite as closely as in the best cases of hand-firing, and such assistance given as may from time to time be required.

When the boilers are fitted with plain grates, the method of firing is too often of an uncertain character, being frequently left to the whim of an unintelligent fireman. It is too often the practice to carry heavy fires, and at times of firing to throw too much fresh coal into the furnaces in one body, all of which contributes to imperfect combustion of the gases and, consequently, loss of economy. Except in cases where low-grade volatile coals are burned, the method of firing which is generally considered the best, both for economy and capacity, is that of carrying a fire of medium thickness, say, 6 to 8 ins., applying the fresh coal in small quantities at a time, covering not over one-half of the entire grate surface at one firing, and leaving a considerable interval of time before the other half is covered. By following this system, an additional advantage is produced, in that the amount of smoke is noticeably decreased. Where the boilers are not overworked and the best conditions in regard to firing and quality of coal prevail, the smoke which is produced is comparatively unobjectionable.

Efficiency.

It is seldom that the efficiency of a boiler in electric service, that is, the proportion which the heat absorbed bears to the calorific value of the coal, exceeds 80 per cent, even where the best class of fuel and the most favorable conditions of operation prevail. Assuming proper attention to the firing, the highest result is obtained in boilers fitted with mechanical stokers, or other means of securing the best furnace results. Where bituminous coals are used the highest efficiency is obtained with the less volatile coals, whether they are fired by hand or by automatic means. In a hand-fired boiler using coal containing from 15 per cent to 20 per cent volatile matter, an efficiency of 75 per cent is readily obtained, whereas a coal containing 30 per cent to 40 per cent volatile matter used in the same boiler and fired with the same care, gives an efficiency of only 60 per cent, and sometimes less.

STEAM ENGINES FOR ELECTRIC POWER STATIONS.

GEORGE I. ROCKWOOD.

General Types.

The selection of the most suitable type of engine for central station railway or lighting purposes is a somewhat easier matter to-day than ever before. For example, all American railway power stations are operating direct-connected compound condensing slow-speed engines. All use steam at what was considered only a few years ago a very high boiler pressure; namely, in the vicinity of 160 pounds pressure per square inch.

The tendency is to make the units at least two and preferably three in number, and of a size as large as can be transported over the railway.

Having agreed, however, upon the size of the engine in any particular case, and that it is to be compound condensing, and to work under a boiler pressure of 160 lbs. to 180 lbs., certain questions of detail begin to assert themselves. There are three quite different kinds of compound engines in the three largest and newest stations in this country. The Waterside Edison plant has vertical three-cylinder compounds, designed on the Rockwood system of cylinder proportions. The Metroplitan Street Railway station has the more common type of vertical cross compound with a cylinder ratio of 1 to 3½. The Manhattan Elevated Railway station has the peculiar but very effective design of two complete compound engines on one crank shaft, the high-pressure engines being horizontal and the low-pressure engines vertical. The cylinder ratio is slightly over 1 to 4. The question arises, "Which is the best of these three types?" For my own part, I should choose the Manhattan type on account of the eight impulses per revolution received by the shaft. But there is no doubt that the economy of the Waterside engines is higher, on account of the larger cylinder ratio. The mechanical objection to the Waterside type of engine is the large number of main bearings, there being four as compared with only two in the Manhattan engines. The power per unit of floor space is very much less in the case of the Waterside than in the much larger Manhattan engines, being in the ratio of 33 to 55. The latter are, however, much more accessible and spacious, while it is a great convenience to have the entire high-pressure engine spread out on the main floor. It is also a good thing to have these gigantic generators separated from each other just as far as possible, in order to minimize the dangers resulting from a short circuit.

Valves.

All of the engines use the Corliss valve. The Edison Waterside station engines, as well as those of the new Rapid Transit station, have poppet valves on the high-pressure cylinders. These valves are of the Sulzer type. They are a necessity, if the boiler steam is to be superheated to 150° above its natural temperature, for the poppet valve, having no sliding action, requires no lubrication. It must be admitted, however, that the Sulzer type of balanced poppet valve is a very trying one to make and keep perfectly steam tight, in the larger sizes. If the valve edges touch their seats all around when cold, then they probably will not do so when hot. A poppet valve is likely to be affected by erosion of the steam while in the act of seating, and needs to be reground occasionally by someone who knows how to do it; and in the attempt to perform this very difficult operation it is as easy to make the fit worse as it is to make it perfect. Again, the poppet valve, unless placed in the cylinder heads, has large clearance space—about 7 per cent.

The Corliss valve has a great history and a wider all-around reputation for giving mechanical satisfaction and economy of steam than either the poppet or the multi-ported slide valve. But this is undoubtedly because it was the first to be widely used in a four-valve arrangement. If it is as good, all things taken into consideration, as the multi-ported slide valve, it is yet very doubtful if it is any better. Certainly present practice is at fault in making such extended use of the double-ported Corliss valve. Without doubt makers of Corliss engines have been impelled to do this by the mechanical success of the slide valve. The Wheelock and the Leavitt and the McIntosh & Seymour multi-ported slide valve engines, in this country, and the Ferranti engines abroad, are as economical and mechanically as successful as any Corliss or Sulzer engines ever were.

The exceedingly short motion of the valve-stem of a multi-ported slide valve, together with the very long closing edge, are the reasons why the slide-valve engines of Ferranti can be run at such high speeds without undue wear and tear of the valve-gear, and with high steam economy.

The clearance volume of an engine having multi-ported slide valves may be very much less than the clearance of a Corliss engine having an equivalent valve area. This is an advantage particularly marked in the case of the low-pressure cylinders of compound engines, for these, owing to their relatively short stroke, usually have from 6 per cent to 9 per cent of clearance, if of the Corliss type, whereas Wheelock engines have but one-half as much clearance.

But the advantage is not all upon the side of the multi-ported slide valve. It suffers from the disadvantage of exposing a far greater area of cast-iron surface to the entering steam than is true of the Corliss valve. This defect tends to neutralize its good qualities; indeed, experience seems to show that in point of economy of steam there is hardly any difference between the best performances of engines equipped with these two types of valve.

The poppet valve engine has been very little used in America. The only type in common use is the Putman engine, and this is limited to comparatively small sizes. In Europe the popularity of the balanced poppet valve is second to none. The economy of European poppet-valve engines is also unexcelled. That it has not met with a more extended use in the United States is due to its far greater first cost as compared with Corliss valves. As previously stated, it is used on the high-pressure cylinders of the Edison Waterside engines, and also upon the Rapid Transit high-pressure engines; but this is because of the intention to use superheated steam in these stations, in which case it is a necessity.

Economy.

The most economical steam engines in this or any other country are found in certain mills of New England and in some recent Corliss pumping engines. By this is meant those engines which provide a brake horse-power on the least consumption of coal per hour. In the No. 4 mill of the Atlantic Mills, Providence, is a small Corliss compound, condensing, slow-speed engine, which gives one brake horse-power on a coal consumption of 1.2 lbs. per hour. The steam consumption of this engine is 11.2 lbs. per indicated horse-power per hour. The conditions were 170 lbs. boiler pressure, 80 r.p.m., and about 500 horse-power developed. The cylinder dimensions are, high pressure, 16 ins. x 48 ins.; low pressure, 40 ins. x 48 ins. This engine has substantially the same cylinder ratio as those of the Waterside station. If the Manhattan engines had been designed with smaller high-pressure cylinders and larger low-pressure cylinders they would have provided the same power as at present, and would have provided it at a cost 15 per cent lower than they now do.

Superheat.

It has yet to be demonstrated that superheated steam effects any real saving of coal. None of the plants of which we have heard so much within the past five years, especially designed to use highly superheated steam, has shown anything like the economy of coal of the Atlantic Mills plant, although they have indeed shown phenomenal reductions in the weight of steam used per indicated horse-power per hour. The superheating not only eats up all it saves but it increases friction and wear, and adds heavily to the first cost and running expenses of the plant.

Reheaters.

That superheated steam does not effect a practical saving when the cost of doing the superheating is taken account of, is shown by the tests of the Cooper Corliss engine, at the Atlantic Mills, both with and without steam in its receiver. With steam in the jacket pipes the temperature of the receiver steam was raised 44° above that normal to its pressure. No saving of heat whatever resulted, however, except the hot jacket drip which was returned to the boiler.

The test of this engine proved, nevertheless, that the reheater coils were worth far more than they cost, for another reason entirely than because of any reduction of the weight of steam per indicated horse-power per hour. It was observed that the reheating of the steam increased the *power* of the engine (without at the same time lowering its economy of operation) by about 12 per cent.

Perhaps a reasonable limit to the amount of surface in the coils per indicated horse-power may be set at one and one-half square feet. A full description of the receiver on this engine may be found in Vol. XXI, p. 908, Transactions A.S.M.E.

Two Eccentrics vs. One.

A detail of engine design about which a good deal has recently been said is the use of two eccentrics instead of one, in order to allow the steam valves to be set without regard to the movement of the exhaust valves. When but one eccentric is used the result is that no governing of the cut-off valve can take place after the piston has moved through about seven-sixteenths of its stroke. Two eccentrics do away with this limitation. Nevertheless, I am opposed to the use of two eccentrics for two principal reasons. First, it is better to have the steam valve open promptly for the normal load rather than to wait for an abnormal load before pulling it clear open, and this is only effected when the timing of the valve movement is the same that a single eccentric would give it. Second, the other eccentric and gear cost money to buy and operate, and increase the number of moving parts to require attention. The only real advantage of two eccentrics is that if there has been any mistake in the construction of valve lap or wrist-plate motion the single-eccentric engine is in a much worse plight than if the adjustments of the valves could be made independently of one another.

Marine vs. Land Practice.

It is a matter worthy of attention, now that stationary engines have finally been built in sizes as large as the engines of fast ocean steamships, to note how little cognizance has been taken by either department (marine or stationary) of what the other has done to secure economy. Consider, for instance, the engines of the Cunard liner *Saxonia* in comparison with those of the Waterside Edison station. Probably the designers of the Waterside plant, where the engines are nearly twice the weight of those on the *Saxonia* but develop no more power, on the average, would be surprised to learn that there is not a fig to choose between the records of coal consumption of these two plants. The *Saxonia* engines have plain slide valves, with piston valves on the high-pressure cylinders, as against the Corliss and Sulzer valves of the Waterside engines. Moreover, the steamship engines run with next to no foundation under them, comparatively speaking. The secret of the difference in valve-gear lies in the fact that no matter how much the ship thrashes about, her engines, once started, *must not stop* for one hundred and seventy hours, more or less.

Whether or not plain slide valve engines would be desirable in an electric power engine, there is one appliance used on the *Saxonia* and on every other large marine engine which stationary engineers would do well to copy. I refer to the Aspinall governor for preventing racing. This device is the simplest means and the surest means known to-day for preventing the dreadful consequences of a runaway engine. It acts by causing the shutting of a butterfly valve in the main steam pipe when the speed of the engine increases 5 per cent above normal. It does not require to be reset every time it has been in use, and, if applied as it is at sea, it will also prevent the stopping of the engine, by re-opening the butterfly valve as soon as speed is reduced.

General.

With regard to the interesting fact that the two upright low-pressure engines of the Manhattan unit required to be slightly inclined towards each other to secure correct alignment with the crank pins, owing to the deflection of the shaft under the great weight of the generator field-magnet, it is desirable to call attention to the practice of Messrs, Hick, Hargreaves & Co., of Bolton, England, of providing swiveling main bearings which will prevent heating resulting from the concentration of the load at the inner, or fly-wheel, edges instead of being distributed uniformly over the face of the journal.

As a final expression of personal opinion on the details of design of large electric power-station engines, I should like to go on record as being opposed to the so-called medium-speed type of engine—the engine which runs at a rotative speed of 125 to 150 r.p.m. The gain in this higher speed is, of course, limited to a less first cost of the unit. Higher speeds than 80 to 90 r.p.m. are antagonistic to both first-rate economy and long life for the valve-gear of the engine.

STEAM PLANT AUXILIARIES.

BY HENRY C. MEYER, JR.

No matter how well the main parts of a steam plant—the engines and boilers—are adapted for their purpose, the plant as a whole will not operate either satisfactorily or economically if the auxiliaries, and by that is meant the condenser pump, feed-water heaters and the like, are not properly arranged and proportioned. Often much thought is given to the selection of engines and boilers when the other details are given little attention. For that reason, when the writer was asked to prepare an article for this issue of the AMERICAN ELECTRICIAN the subject indicated by the title was selected in the belief that a brief discussion of the auxiliaries of a plant, their adaptability and advantages might prove of interest.

Condensers may be divided into three general types known as surface, jet and siphon condensers. In the surface condenser the steam is condensed by being brought in contact with brass or copper tubes against the other surface of which cold water is circulated. As the condensed steam does not come in contact with the cooling or circulating water, water unfit for boiler feeding can be used for cooling, and the condensed steam can be led to a hot well from which it can be again pumped to the boilers. This feature would make the surface condenser of great value in stationary plants where boiler water is costly, but for the fact that the water becomes impregnated with cylinder oil so as to make its repeated use inadvisable. On shipboard danger from oil is overcome by the use of cloth filters, which are given almost daily attention, the cloth being removed and replaced at frequent intervals. All kinds of filters have been used in stationary plants, some with a fair degree of success, but only when given the most careful attention. It is much to be regretted that some method has not been found for removing all of the oil from steam exhausted by engines, for the cost of water for boiler feeding in some of the largest electric generating stations amounts to a good many thousands of dollars annually. The cooling water for a surface condenser is sometimes supplied by a pump attached to the air pump, often by centrifugal pumps, the latter being especially applicable when the lift is a low one.

In a jet condenser the steam and cooling water are led to a chamber where they mix, the water condensing the steam. The mixture and also the air is removed by the air pump. Because of the fact the condenser discharge is at a fairly high temperature (about 120° Fahrenheit), the boiler feed pump, when the cooling water is fit for boiler feeding, is frequently arranged to draw its supply from the condenser discharge. As the volume of cooling water is many times the volume of condensed steam almost all of the oil in the steam passes to waste with the condenser discharge because the boiler feed pump only receives from one-twenty-fifth to one-thirtieth of this discharge. Of course, in this type of condenser the feed water cannot be drawn from the air pump discharge if the cooling water is unfit for boiler feeding. If plenty of water is available at low cost and there is sufficient steam exhausted by the pumps and other auxiliaries running non-condensing to warm fresh water to about 200° Fahrenheit, the writer believes in allowing all of the condenser discharge to go to waste, even if the small part of it that would be required for boiler feeding contained but a small amount of oil. Oil has given more trouble than many engineers suspect.

The catalogues of condenser manufacturers sometimes show, in the illustrations, the air pump arranged to exhaust into the condenser, in order to obtain for the steam cylinder of the air pump the benefit of the vacuum that the condenser creates. This arrangement should not be made use of if there is not sufficient exhaust steam from the auxiliaries to heat the feed water to about 200° Fahrenheit, for the reason that it would be more economical to use the air pump exhaust for boiler-feeding than it would be to run the air pump condensing. If the exhaust steam is used for heating, almost all of the heat in the steam entering the air-pump cylinder would be returned to the boiler with the feed water, whereas if the air-pump exhaust were turned into the condenser, most of the heat in the steam would go to waste, passing out with the air-pump discharge, or into the cooling water if the condenser is of the surface type. Of course, the latter method will save some steam because of the benefit of the vacuum, but this saving will not balance the higher efficiency that follows the use of the air-pump steam for heating as described.

In the siphon condenser the steam and cooling water are led to an elevated head or cone, when they mix and then fall through a pipe about 34 feet long to a hot well beneath, or to waste. The velocity of the falling water causes a partial vacuum to exist in the condenser, and after the supply of cooling water is started the vacuum causes it to rise freely some distance, usually 15 or 18 feet. Where plenty of condensing water under pressure is available, as it sometimes is in mills located below a dam erected for hydraulic power purposes, a pump is not necessary to supply the cooling water. Recently the siphon type of condenser has been greatly improved, and it is now used in some of the largest plants, one condenser being furnished for several engines. This condenser is exceedingly simple, and not likely to get out of order.

Perhaps the most frequent error made in purchasing condensers is in having them too small, for a high vacuum means a good deal in these days of compound engines run with low mean-effective pressures. There used to be an impression that too high a vacuum meant a loss in economy, for with the higher vacuum the exhaust steam would have a lower pressure, consequently the air pump discharge would be cooler and the feed water of lower temperature. A few degrees in feed-water temperature has much less effect, however, upon the economy of a plant than a slight difference in the degree of vacuum attained.

Various methods of driving air and circulating pumps for condensers are used. Usually it is a direct-acting steam pump or a modification of it. Crank and fly-wheel pumps are also used, so that the steam can be worked expansively. In a few instances the air pumps, and even the boiler feed pumps, are driven by electric motors, but not with the greatest success. In a modern well-designed plant operating with condensers there is hardly sufficient steam exhausted to heat the feed water to 200° temperature, and for that reason the wisdom of driving the auxiliaries electrically is not apparent when it costs so little under these circumstances to drive them by steam. The steam-driven air pump is very simple, and not likely to get out of order. The amount of steam that it uses is not of much importance when the steam exhausted by the pumps can all be used for heating. One advantage of the steam-driven air-pump is that its speed can be governed to suit the load upon the engine. Air pumps driven from the crank pin of the main engine are now almost out of date.

Feed-water heaters are of two types, the open and the closed, and both have their advantages and their disadvantages. The closed heater is similar to a surface condenser; in fact, it acts like one. In the open heater the steam and water mingle in the heater chamber, and in this respect they resemble the jet condenser. The objection to the open heater lies in the fact that although most of the oil in the exhaust steam can be removed by an efficient grease separator, it cannot be wholly eliminated—a fact which renders this method of heating undesirable for certain purposes. On the other hand this type of heater is well adapted for utilizing the returns from heating systems, the condensation in pipes, etc., as the return water and condensation can be led directly to the heater. With the closed heater, a return tank to which all condensation is led, and an automatically-governed pump in addition to the regular feed pump, are necessary, if the heating returns and other condensation is to be returned to the boilers. This pump is usually connected to the water supply piping between the feed pump and the boilers. With the open type of heater, the feed pump is connected between the heater and the boilers, and as the pump has to handle hot water it must be adapted for this purpose.

When feed water contains scale-forming salts that are precipitated below a temperature of 200°, the open type of heater should be used in preference to the closed type. Closed heaters are usually proportioned, or should be proportioned, so that they contain one square foot of heating surface in brass or copper tubes for every 90 pounds of water passing through the heater per hour, assuming that the water is to be heated from about 60° to 200° Fahrenheit with steam at atmospheric pressure. While a heater, when new, will do much more than this, it should not be forgotten that the heating surface soon becomes coated with grease, and its efficiency will then be impaired. Probably no part of a steam plant (unless it be pipe covering) produces a greater saving per dollar of investment than a good feed-water heater; hence an owner should not try to save money by buying one that is too small for the work it is to do.

There are numerous methods of heating feed water. If the plant is running condensing, the feed water might be drawn from the air-pump discharge, in which event its temperature would be a little over 100°. It could then be passed through a feed-water heater to which would be led the exhaust steam of all auxiliaries, such as air pumps, boiler feed pumps, stoker engines and perhaps exciter engines, if there be any. The water would then be heated to about 200°, as the exhaust steam would not have a temperature much above 212 degrees. The feed water could then be passed through an economizer and heated considerably, the extent of heating depending upon the amount of economizer surface and the temperature of the waste gases.

In some condensing plants where there is barely sufficient auxiliary exhaust steam to heat the feed water to 200°, the water is first passed through a closed heater connected in the exhaust pipe between the main engine and the condenser, after which the water is further heated in the auxiliary heater. In order that the efficiency of a feed-water heater may always be known, it is well to provide in the feed line near the boiler a thermometer to show the temperature of the feed water.

Economizers perform the same function as feed-water heaters, but they obtain the heat from the discharged furnace gases, of course, instead of from exhaust steam. It is safe to say that most boilers have to be driven at such a rate that a greater proportion of the heat of the fuel passes up the chimney than would accord with good boiler practice. An economizer will intercept and return to the boilers a large part of the heat that would otherwise go to waste, hence it is of no little value, particularly when fuel is costly. There is less opportunity for an economizer to save fuel when exhaust steam is available for boiler feeding, for then the economizer would receive water that was already heated to about 200° temperature. Even under these conditions, an economizer will probably save sufficient fuel to make its use advisable with coal of moderate cost. Owing to the reduction in flue temperature due to their use and to the resistance they offer to the flow of the flue gases, economizers necessitate the provision of a strong draft, which means either ample chimney capacity or mechanical draft.

STEAM PIPING IN MODERN POWER PLANT PRACTICE.

BY CHAS. W. OLIVER.

The trend of progress in power plant practice during the past two years gives evidence of far greater attention and care paid to that important connecting link between the boilers and engines—the steam piping system—than was formerly thought necessary. The importance of the most careful attention paid to the details of the piping, as well as to the arrangement of connections to provide for duplication, is being fully recognized, as may be ascertained by an inspection of the more recent plants.

There has been, during the past few years, a marked tendency toward the provision of absolute duplication in steam piping layouts by the installation of two separate and distinct systems of headers and connecting piping, each of sufficient size to carry the entire load of the plant. This was a result of the many experiences of shunt-down and interruptions due to piping troubles, in the earlier days of central station practice, and was only a natural consequence of the unsystematic arrangements of plant apparatus, initially in vogue.

With the improvement of the power plant facilities and the introduction of more liberal ideas as to apportionment of reserve generating capacity, however, the necessity of absolute duplication has been reduced to a practically negligible point. The tendency even seems to be toward avoiding the laborious work of installing the extra apparatus for the duplication. But in some cases, the requirements of the service, or the particular arrangement of the apparatus, require duplication of the steam mains in order to insure constancy of service. Several cases may be named of this class, one of which is the power plant of the John B. Stetson Company, at Philadelphia, Pa., which was illustrated and described in the November, 1902, issue of the AMERICAN ELECTRICIAN. In this installation the boilers are not located adjacent to the engine room, as is now considered to be the preferable arrangement, but are situated in two separate rooms located at some distance from the engine room. This arrangement renders the entire service of the plant practically dependent upon the connecting steam main between the boilers and engines; for this reason a duplicate main was carried through the two boiler rooms and connected to the boilers on the "ring" system. It is, of course, unwise to allow the continuity of service of an entire plant to become dependent upon a single line of steam pipe stretching between a widely separated engine and boiler room.

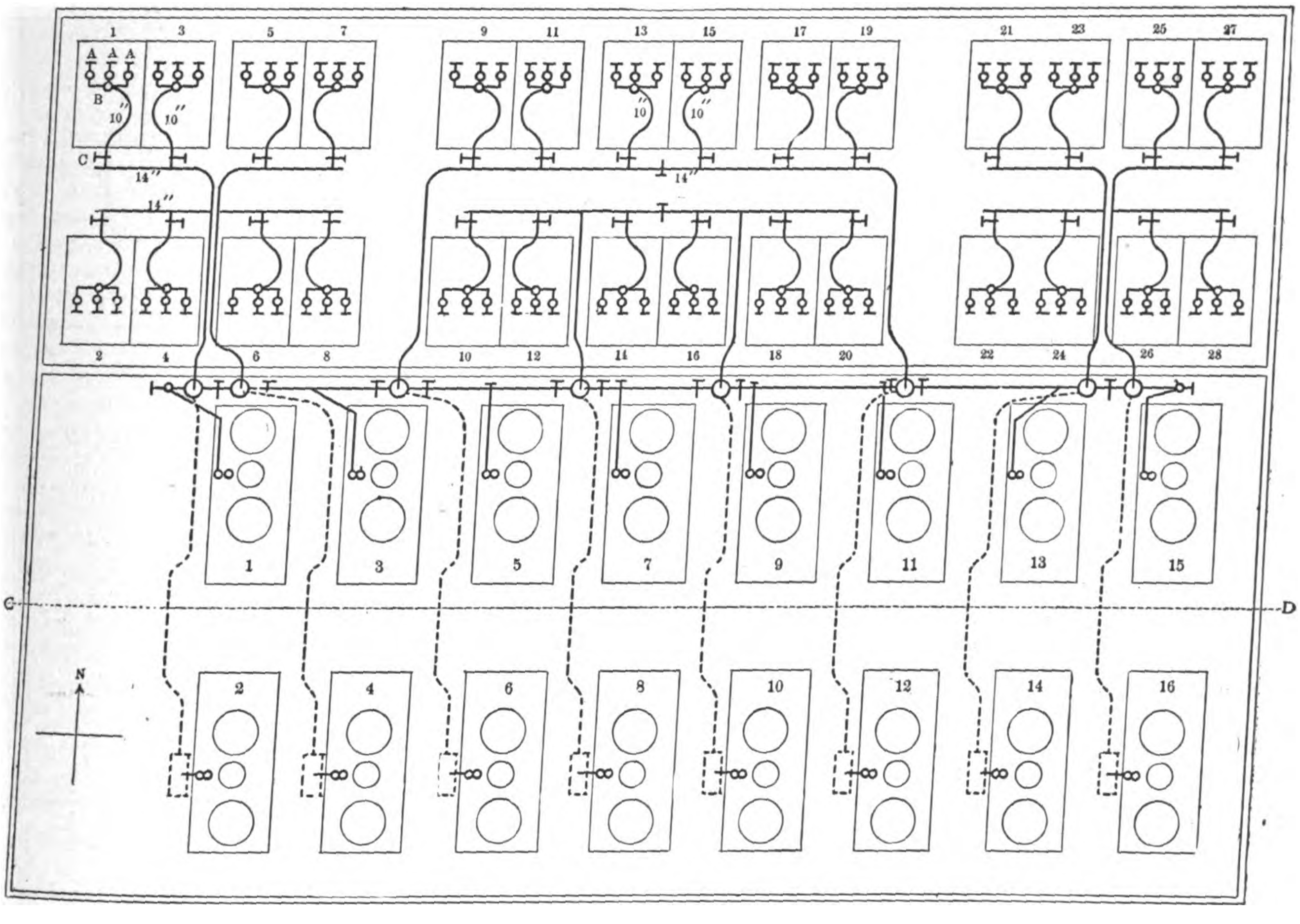

FIG. I.—STEAM PIPING PLAN OF NEW YORK EDISON WATERSIDE STATION.

Another case of similar nature that may be cited is the remodeled plant of the Georgia Electric Light Company, Atlanta, Ga., which was described in the October, 1901, issue of this magazine. In this installation the piping system consists of two duplicate main headers in the boiler room, each of which is connected to every boiler of the plant. Both headers lead over to all the engines so that any engine may be operated from either header or from both. This arrangement was also a result of separated engine and boiler rooms, due, no doubt, to the irregularities resulting from the rapid growth which this plant experienced.

Still another case of duplication of the piping system is to be found in the power plant of the Westchester Lighting Company, at New Rochelle, N. Y.; described in the March, 1902, issue of this magazine. In this case every boiler is connected so as to be able to feed into either of two duplicate 16-in. steam headers, and several of the engines and all the auxiliaries are fed in duplicate from the two headers on the "ring" system. The two larger engines of the plant are individually fed through 6-inch pipes from one of the headers only, being supplemented by additional connections through reducing valves to the low pressure cylinders from the other main header. This is an excellent arrangement, particularly on account of the comparatively large sizes of the units installed, but as more units are installed for similar service the duplicate piping will be found of less value.

The tendency in modern plants of moderate size seems to be, however, that of avoiding the duplication of the entire piping system by a parallel arrangement of the engines and boilers in their respective rooms. This is entirely practical without losing the advantages of the duplication where several boilers are arranged in a row along one side of the division wall and the engines similarly located on the other side, with a common interconnecting main steam header, equipped with sufficient section valves, between; in a plant thus subdivided, if a section of the steam main becomes disabled, the sections and apparatus on either side of the disabled portion are not in the least affected. The greatly increasing number of plants that are being equipped in this manner of late gives evidence of the success of this method of providing for the duplication. With this arrangement of plant, when supplemented by the highest grade of workmanship in construction and installation, the single longitudinal header arrangement is proving highly satisfactory in service.

An example of a plant thus arranged is to be seen in the district supply station of the Central Electric Company, located at Metuchen, N. J., which was fully illustrated in the July, 1902, issue of this magazine. In this plant the two 600-h. p. boilers and the two corresponding engines are arranged parallel on opposite sides of the separation wall, and are all interconnected to a single 12-inch steam header; this permits of either boiler operating either engine, or combinations of the two. The header is sufficiently divided up by gate valves so that any combination may be made.

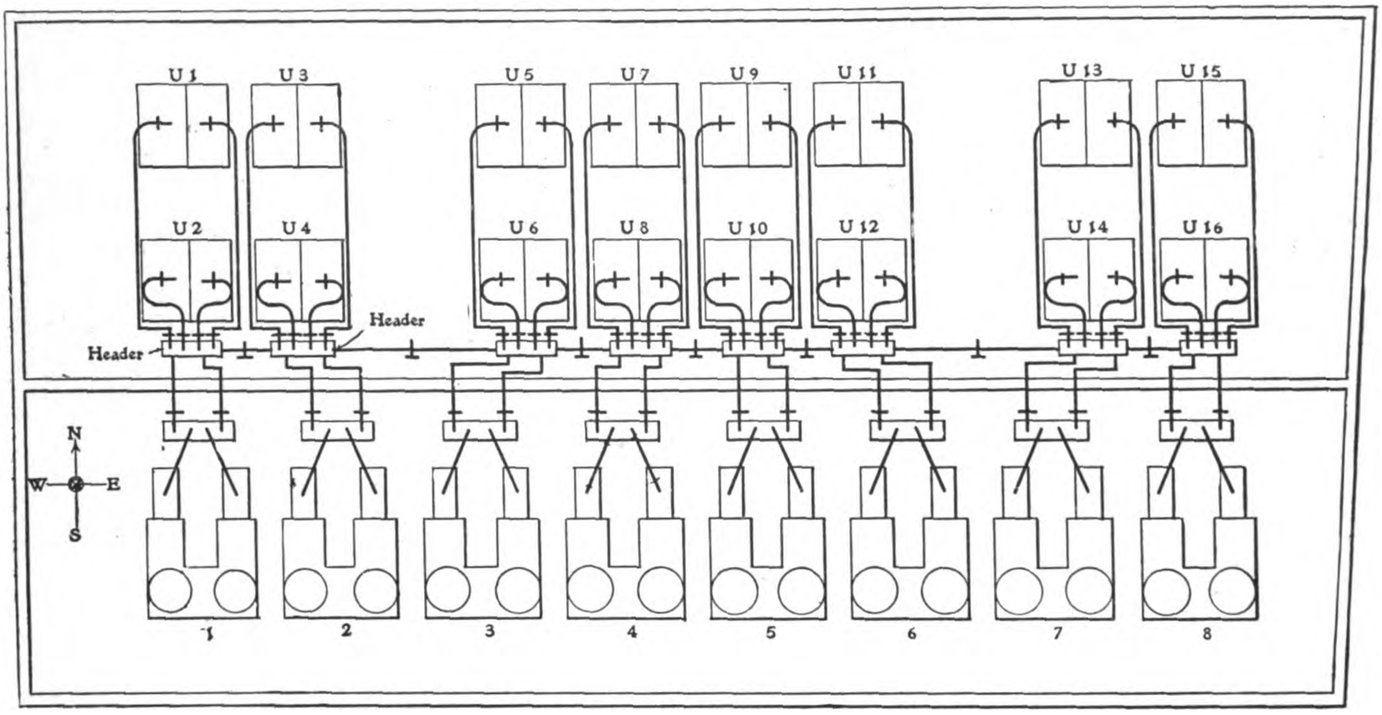

FIG. 2.—STEAM PIPING PLAN OF THE MANHATTAN ELEVATED RAILWAY POWER STATION.

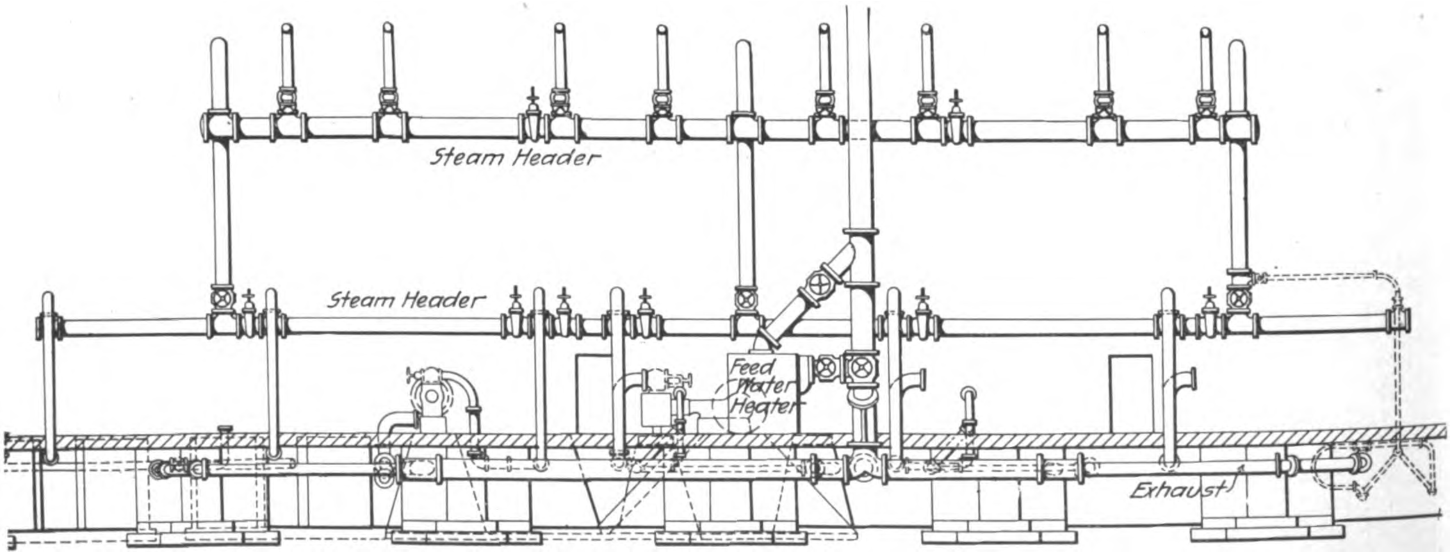

FIG. 3.—SIDE ELEVATION OF DOUBLE-HEADER PIPING SYSTEM.

The argument against this arrangement has been that an accident to the header pipe will disable the entire plant, but it does not hold. When a header is subdivided into sections by valves, it requires an extreme case of disablement to shut down the plant entirely. If either end of the header is disabled, that portion may be entirely cut off and thus not interfere with the other, so that the boilers and engines at the other end may continue in operation. If the middle section of the header is out of order, it may be cut out, with the result of merely preventing any cross communication between the units at either end; but the units will not in that case be withheld from operation.

The only tenable argument against this arrangement is that cross communication between the engines and boilers at either end is impossible when the section of the header in the middle is disabled; but this amounts to nothing when the generator units are all of similar type, which is now becoming general practice as a result of the desire to generate only one kind of current for all classes of service. In stations thus equipped the generator units are all of similar type and frequently all of one size, so that it makes very little difference what unit is in operation.

An example of the last mentioned arrangement of plant and piping is to be found, on a very large scale, in the plant arrangement of the Waterside Station of the New York Edison Company. The piping arrangement for this plant, when completed will be the largest in aggregate output in the world, is shown in Fig. 1. As may be seen, all of the delivery pipes from the boilers are interconnected by a single longitudinal header, as above mentioned, although on a very extensive scale. The principle does not differ, however; each engine may be so connected as to be operated from the single battery of boilers immediately adjoining, or from others, through the interconnecting header.

The same applies in the Manhattan

Elevated Railway power station in New York City, which is so widely known for its equipment of 8,000-h. p. engines. A diagram of the piping in this plant is shown by Fig. 2. In this arrangement the boilers on both floors of the boiler section feed, in batteries of four, into 18-inch drums, which are interconnected so as to form practically a continuous single header extending the length of the building. There is a header of this nature on both of the boiler floors, from each of which the supply for the engines is drawn. This arrangement, as well as that in the previous case strictly avoids duplication, and has been found in practice to embrace all the advantages of the duplicate system.

Where this parallel arrangement of boiler and engine units is possible, and the machines driven are of the same type and thus interchangeable in service, it is not evident how the increased expenditure involved in the duplicate steam header arrangement is warranted. Inasmuch as the single interconnecting header in plants of this nature practically fulfills the purpose of the duplicate system, it is advisable not only on account of the reduction of cost, but also for the simplification of connections.

Figs. 3 and 4 illustrate an interesting arrangement of piping in a plant arranged for a peculiar mixed service of direct and alternating current and compressed air. It is in a power plant operated by the Philadelphia & Reading Railway Company at Reading, Pa. On account of the importance of freedom from interruptions of service, the piping arrangement shown was resorted to and has met with very gratifying results in service.

In this plant two steam headers are used, an intermediate header and the usual main header from which the engines are connected. The upper, or intermediate header, is located near the steam outlets of the boilers and to it all of the boilers are connected. The main header is located below and near the fire wall. Three feeder mains, fitted with gate valves, are used to join these two headers, so that steam may be conducted to the lower main in a number of different channels in case accident to any part makes it necessary. This is, in reality, merely an extension of the well-known "ring main" principle of piping adapted to the particular conditions here met. This arrangement serves the desired purpose of duplication in a most admirable manner, and still avoids the complication of valves necessary with the usual duplicate header arrangement.

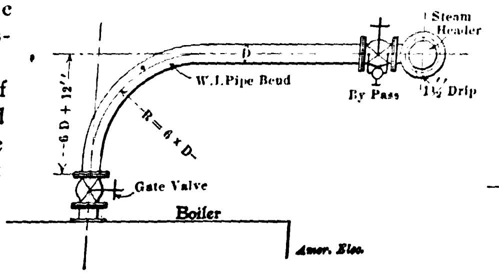

FIG. 5.—GOOD DIMENSIONS FOR VERTICAL BENDS.

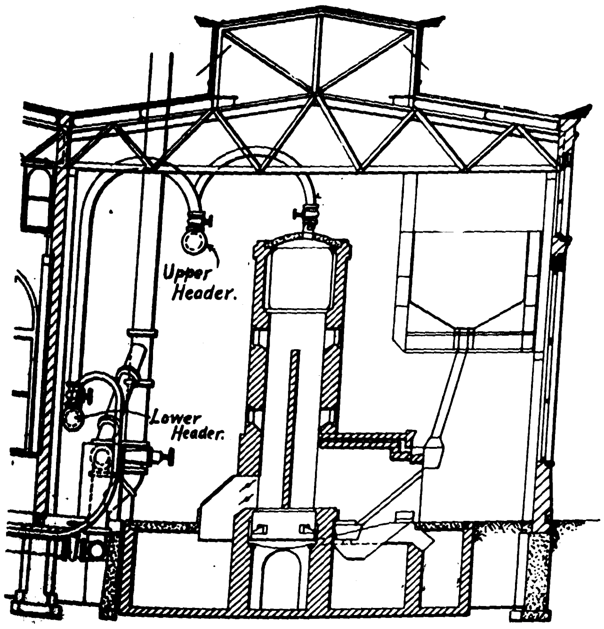

FIG. 4.—END ELEVATION OF DOUBLE-HEADER PIPING SYSTEM.

A notable feature of the piping arrangement in the Reading power plant is the method of taking all connections from the upper sides of the headers in order to reduce the tendency of the steam to entrain water of condensation. A complete system of drips is in use, the condensation being removed by a Holly Steam Loop system which returns it to the boilers, and there has been absolutely no trouble from water of condensation at the engines.

In contradistinction to the excellent results obtained with the arrangement last described may be mentioned the unfortunate experiences met in a certain power plant in the West which was completed last September. One 150-h.p. engine and three 500-h. p. engines are connected up and operated on the single longitudinal header arrangement, but the engine connections are all taken from the lower side of the header in order more easily to make basement connections to the engines. This results in all condensation pocketing in the header being drained directly down into the engine connections, and the separators, although apparently sufficiently large, were totally unable to remove the water. The result has been unlimited trouble with water in the cylinders of the engines, and a broken throttle valve in one instance. This goes to show more forcibly than ever the absolute necessity of providing for condensation in steam piping.

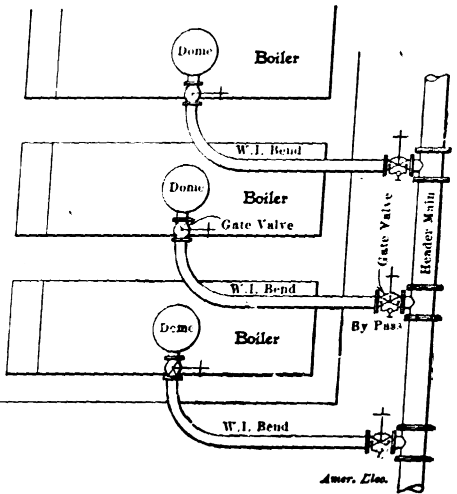

FIG. 6.—ARRANGEMENT OF HORIZONTAL PIPE BENDS.

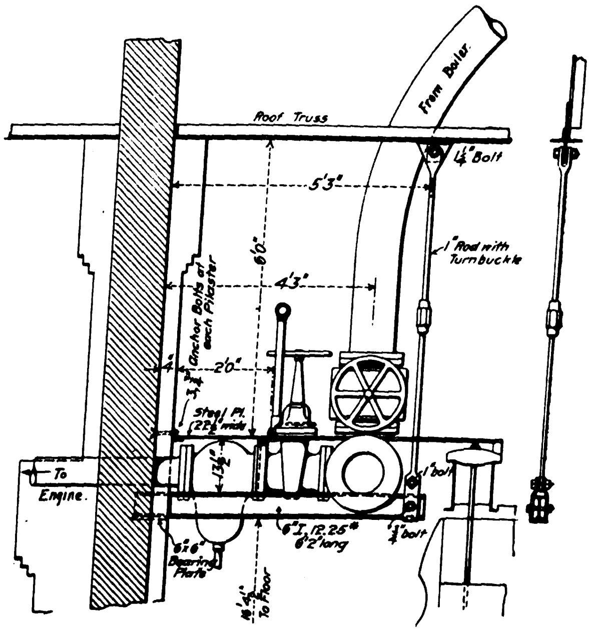

FIG. 7.—CONVENIENT METHOD OF SUSPENDING PIPE MAINS.

The best practice in steam-piping seems to be tending toward the application of supplementary drainage systems of 1¼ or 1½-inch pipe for steam headers. In one large plant a 1½-inch drainage pipe was run the entire length of the steam header, cross taps being made into it at every point where water is liable to "pocket." Numerous instances may be named where smaller drainage pipes (1 inch to 1¼-inch) have been used in similar manner. In all these cases the drainage pipe is connected to a steam trap or other means are provided for constantly draining the system of water. It is very necessary that this feature of piping systems should be given the most thorough consideration, because condensation cannot be wholly prevented.

The diagrams, Figs. 5 and 6, illustrate typical header connection arrangements to boilers. Fig. 5 shows the preferable method, using a vertical bend so as to permit of no "pocketing" of condensation in the connecting pipe. With this arrangement the header may be tapped at the lower side for a drain as shown. It is important that the drainage pipe be large enough—experience seems to indicate that a 1½-inch pipe and connections are none too large for ordinary isolated plant practice, while even larger sizes may be used to advantage. This sketch also indicates the usual proportions for the long radius bends in the piping. A large number of installations have been made according to these proportions, which have been found very satisfactory. Where there is plenty of space to spare the bends may, of course, be made of greater sweep, but the proportions here shown are common in practice.

If the head room above the boiler does not permit of the use of a vertical bend, the bend need not necessarily be prohibited; Fig. 6 indicates a horizontal bend arrangement which is largely used in office buildings and elsewhere in cramped spaces. In such cases the boiler connection should be drained as well as the header.

The remaining sketch, Fig. 7, illustrates an interesting pipe-gallery-support that has recently been installed in a new 800-h. p. power plant. It is a very interesting and serviceable arrangement for supporting the header, providing easy access to the piping and valves. It is located at the rear of the boilers and is supported partly by the division wall and partly from the roof trusses. Along this gallery runs a main 10-inch steam header to which all boiler and engine connections are made. Next to the wall is arranged a walk-way of 22½-inch steel plates with a railing 2 ft. from the wall, which makes a very convenient working platform for handling the valves and caring for the piping. This gallery is also arranged so that access may be had from it to the economizer and exhaust fans.

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American Institute to Publish Graduating Students' Theses.—At a recent meeting of the board of directors of the American Institute of Electrical Engineers it was decided to request the head of the electrical-engineering department in each of the universities and technical schools in which local Institute meetings have been held during each year to select from the theses of each year's graduating class the one which in his judgment is of superior merit and a valuable contribution to electrical-engineering work. Those which are of superior excellence will be chosen and printed in full or in abstract in the Transactions of the Institute.

ELECTRIC HAULAGE ON FRENCH CANALS.

BY GEORGE E. WALSH.

The enlargement of the Erie Canal by the State of New York revives the question of electric haulage. To continue using mule-haulage on the canal would be very much like returning to the old stage-coach system of transportation of passengers. Nevertheless, while electric haulage of canal-boats appears to be the only sensible and reasonable method of solving the problem, and experiments have been made repeatedly with various systems, no such system has come into commercial service in this country.

Unquestionably we are entering upon a great era of canal building. In Europe and America more money is being invested to-day in canals than in new railroads. With the Erie canal enlargement and the Panama canal put through, we shall lead all other countries in a few years in canal-building; but England, Germany and France in the past have been the most extensive builders of these waterways. Even little Belgium has spent upward of fifty millions of dollars for canals in the last quarter of a century, while Holland is famous as a canal-builder.

During the past quarter of a century France has opened up over 400 miles of new canals, and improved some 500 miles of river traffic by enlarging the narrow parts. In all this time her traffic by canals has steadily increased much faster than railroad transportation. Moreover, France has been one of the most progressive of nations in keeping the canal systems up-to-date, and experiments have been made on them in electric haulage which easily places her foremost among the nations in this respect. In order to hold their own with the railroads canals must have some system of quicker haulage. In France three different systems of mechanical haulage on the canals have been tried, and some or all of them are in more or less successful operation to-day.

The first of these systems is old. It consists of a cable running along the banks, to which the canal-boats are attached by means of clutches. So much confusion was experienced in shifting the boats at various points by this system that it was never extensively adopted. The power required to drive the cable was also found to be more costly than mule-haulage. Several power-houses had to be established along the route to pull the cables, and the cables could not be very long owing to the danger of snapping or overloading. The pull on the cables was not constant, and the boatmen had more or less trouble and inconvenience all along the route.

The second system provided the canal-boats with small electric motors. But the old trouble of damage to the sides of the banks hampered this system. The motor could only be used to drive screws or stern wheels, and the churning of the water by them created waves and eddies which steadily washed away the banks. But for this fact, the system would have proved the ideal one; the impossibility of avoiding the damage to the banks, however, made the second system practically of little use, and its abandonment is merely a question of time.

The third system consists of a track running alongside the canal, with an electric locomotive to haul the boats. In the various modifications of this system there have been tried locomotives capable of hauling whole fleets of canal-boats, and smaller ones that would tow only two or three. The electric power in all these instances has been supplied from overhead trolley wires, although several attempts have been made with locomotives supplied with storage batteries. These single locomotives operated on tracks on one side of the canal have proved more or less failures for various reasons. The cost of operation has always been one of the most important considerations in substituting electric power for mules or horses, and in all of the systems mentioned the cost of operation and installation has been too high.

The latest experimental system on the French canals is one that has been in operation for a short time at Bauvin, not far from Lille, where the northern canal system secures the bulk of the heavy traffic. In this system the boats are hauled by an electric automobile. No rails are needed along the track, but simply good, firm and uniformly well-graded roads of twenty to thirty feet in width. With such roads provided on either side of the canal the hauling is a simple matter for the automobile. This machine is heavy in weight and construction, and capable of furnishing sufficient traction to haul an enormous load. In appearance it is not unlike an American steam road roller. The wheels are provided with very wide rims, so that no trouble will be experienced in going over rough places in the roads, and in the spring of the year when the roads are soft and spongy the wide wheels will not sink into the soil. The automobile weighs a trifle over 2½ tons, and is capable of towing three canal-boats at an average speed of 1½ miles an hour. With further improvements made on these haulers, it is expected that the boats can be towed at the rate of two miles an hour, or even three.

If each canal-boat carries a cargo of 250 tons, a total cargo of 750 tons can thus be transported through the canals much faster than by the old system. By means of the electric haulage system coal is transported at the rate of $1.10 per ton over a distance of 200 miles, which is one-half the charge by rail.

Both at Bauvine and Bethune the new electric automobile is in use, and its operation has proved so satisfactory that a company is building machines as rapidly as possible to handle all the traffic in this northern canal system. Electricity is also being used to operate the locks of the canal, some of which are the largest and most up-to-date in the world. The old-style locks are very rarely seen to-day on any of the French canals, and their disappearance is fully as important as that of the old tow-horse.

American Steam Engines for Electric Light and Power Service

By H. F. Schmidt.

Stationary engines may be classed under one of three general heads, namely, slow-speed, medium-speed, and high-speed engines. Generally speaking, the slow-speed engines are characterized by speeds of 100 r.p.m. and under, a stroke of 42 to 72 inches, separate admission and exhaust valves, the former operated by a detachable cut-off mechanism; side cranks, occasionally displaced by the center to meet special conditions, and regulation by means of a fly-ball governor. Following, and to some extent overlapping, come the medium-sized engines, turning at 100 to 175 r.p.m., having a stroke of 24 to 42 inches, four valves positively driven either by one or two eccentrics, side-crank construction, and automatic shaft governor. The high-speed class, in all but a few cases, has but one valve, controlled by an automatic shaft governor, which changes the travel or angular advance of the valve or both; center crank construction, and forced lubrication with the running parts inclosed to prevent the throwing of oil.

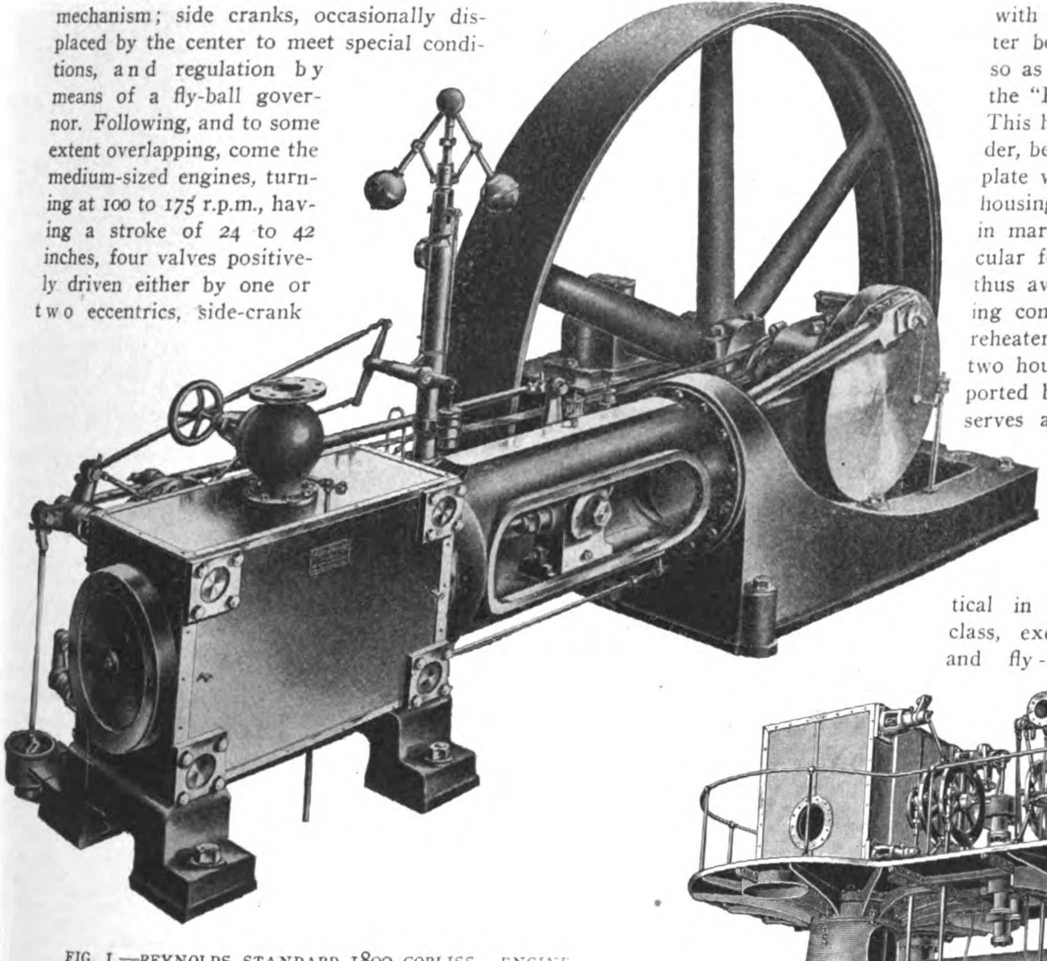

FIG. I.—REYNOLDS STANDARD 1890 CORLISS ENGINE.

This classification is not rigidly correct; a classification by piston speeds would probably be more accurate, for it is the piston speed which determines the dimensions of the engine as well as the size and weight of the foundations required for a given output. On the other hand, the number of revolutions per minute determines the type of valve gear that is most suitable, and therefore is for the purpose of this article a more convenient basis of classification.

The standard 1890 engine shown in Fig. 1 is one of the several types of

Reynolds Corliss Engines

manufactured by the Allis-Chalmers Company, Chicago, Ill. As is clearly shown, it is of the heavy duty design, so constructed that the main bearings are rigidly supported, and all lateral strains are avoided. The designs of the Allis-Chalmers Company include simple and multiple expansion Corliss engines, equipped with either the long or short range cut-off valve gear. These are constructed in the horizontal, vertical and combined horizontal and vertical types. The heavy duty frame of the standard 1890 engine, shown in Fig. 1, is built in two parts; this construction facilitating boring the guides and facing and finishing the journal seat on the bed proper. The main bearing brasses are babbitt lined, with lateral screw adjustment of the quarter boxes, the lower box being also made so as to be easily removed. An engine of the "Philadelphia" type is shown in Fig. 2. This has a separate housing for each cylinder, being of course bolted to the same bedplate which holds the main bearings. The housings are modified A frames, familiar in marine practice; they are made of circular form of a single thickness, however, thus avoiding the box construction requiring complicated patterns. A receiver and reheater spanning the space between the two housings rests on heavy brackets supported by the frames. This receiver thus serves as a connection between the high and low-pressure cylinders. Two variations of this engine are also built, that known as the "Chicago" type and the other as the "Cincinnati" type. The former is practically identical in design with the "Philadelphia" class, except that it has the generator and fly-wheel between the housings, while in the "Cincinnati" design the fly-wheel is between the frames and a generator is connected to each end of the shaft. Fig. 3 hardly needs any comment, having been so frequently the subject of a discussion

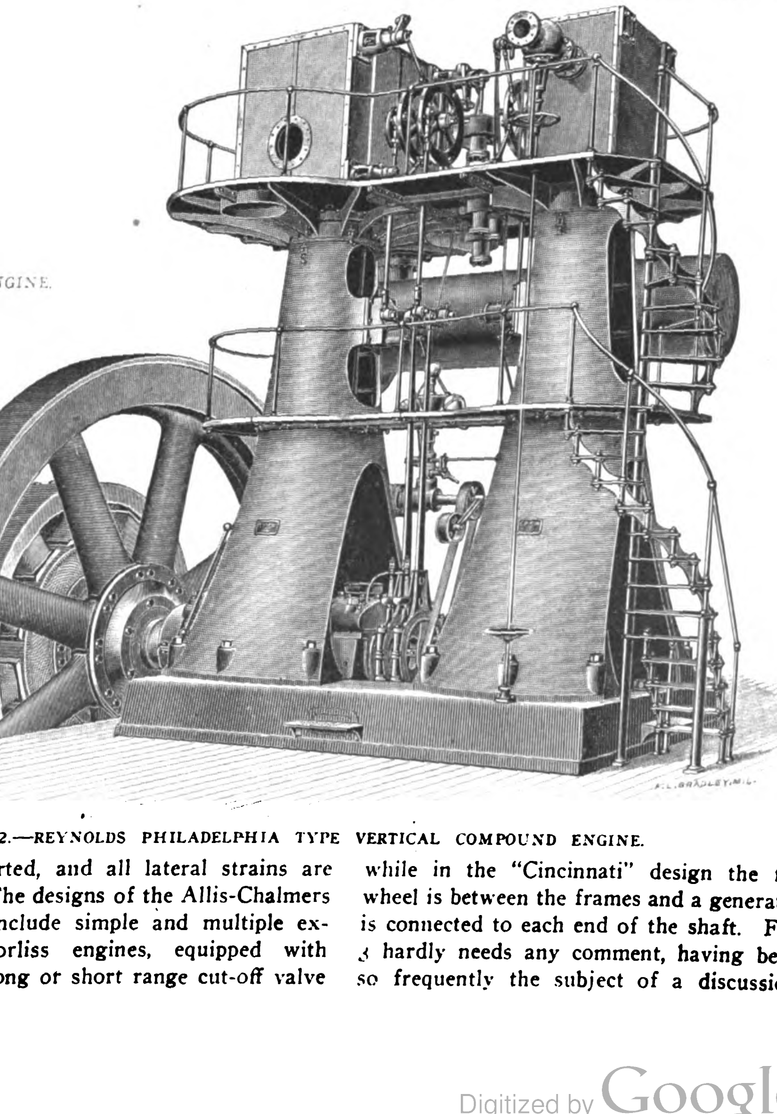
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FIG. 2.—REYNOLDS PHILADELPHIA TYPE VERTICAL COMPOUND ENGINE.

during the past two or three years. It is presented, however, as it illustrates an example of twin combined horizontal and vertical engine. Although having but two cranks, it gives the even turning movement of a four-crank engine. The advantages of this over either a simple horizontal or vertical arrangement are: First, the connecting rods acting on the same crank pin are at right angles, securing a quartering effect with one crank; secondly, the excessive wear that would take place in a low-pressure cylinder of these dimensions is avoided by placing it vertically, and the comparatively small high-pressure cylinder with a correspondingly light piston, horizontal; lastly, saving of space and convenience of the arrangement. The valve gearing used on all these engines is that originally designed by Mr. Edwin Reynolds, now chief engineer of the Allis-Chalmers Company, and which is used with slight variations by the majority of American engine builders. It differs from those commonly used, however, in having the drop lever keyed to the valve spindle within the valve bonnet, on which the bell crank and knock-off cam are mounted, thus relieving the valve stem of all unnecessary strain and giving it a firm support. The valve gear was described fully in the American Electrician exactly one year ago.

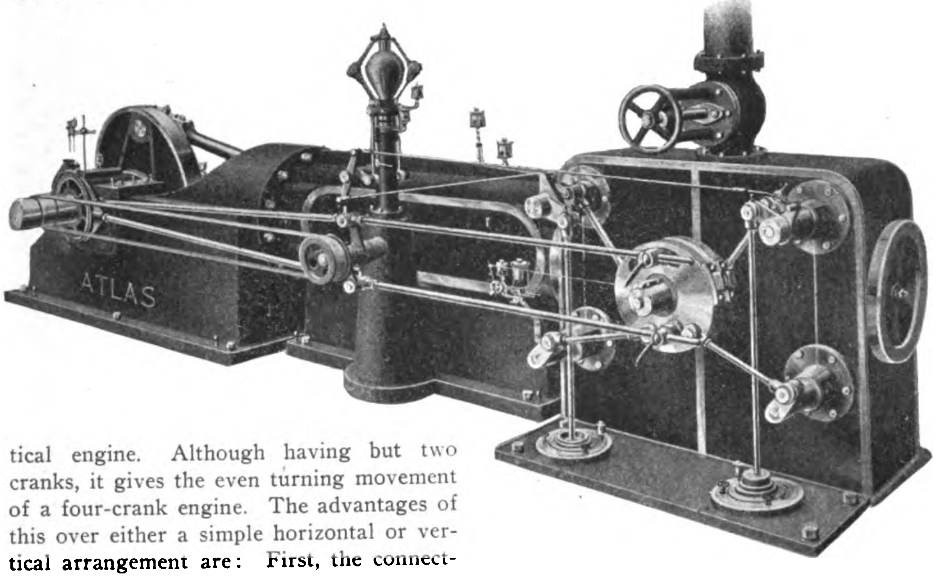


FIG. 4.—ATLAS CORLISS ENGINE.

Atlas Corliss Engine

The Corliss engine illustrated in Fig. 4 is the girder-frame type manufactured by the Atlas Engine Works, Indianapolis, Ind., who are also makers of an extensive line of side-crank and center-crank automatic high-speed engines of the tandem and cross-compound classes. A wide departure from the standard design of horizontal cylinder is made in that the cylinders are divided into three parts cast separately and united together by studs. The barrel of the cylinder is a separate casting, to which are bolted the valve boxes which form the heads of the cylinder, as is often done in vertical engines.

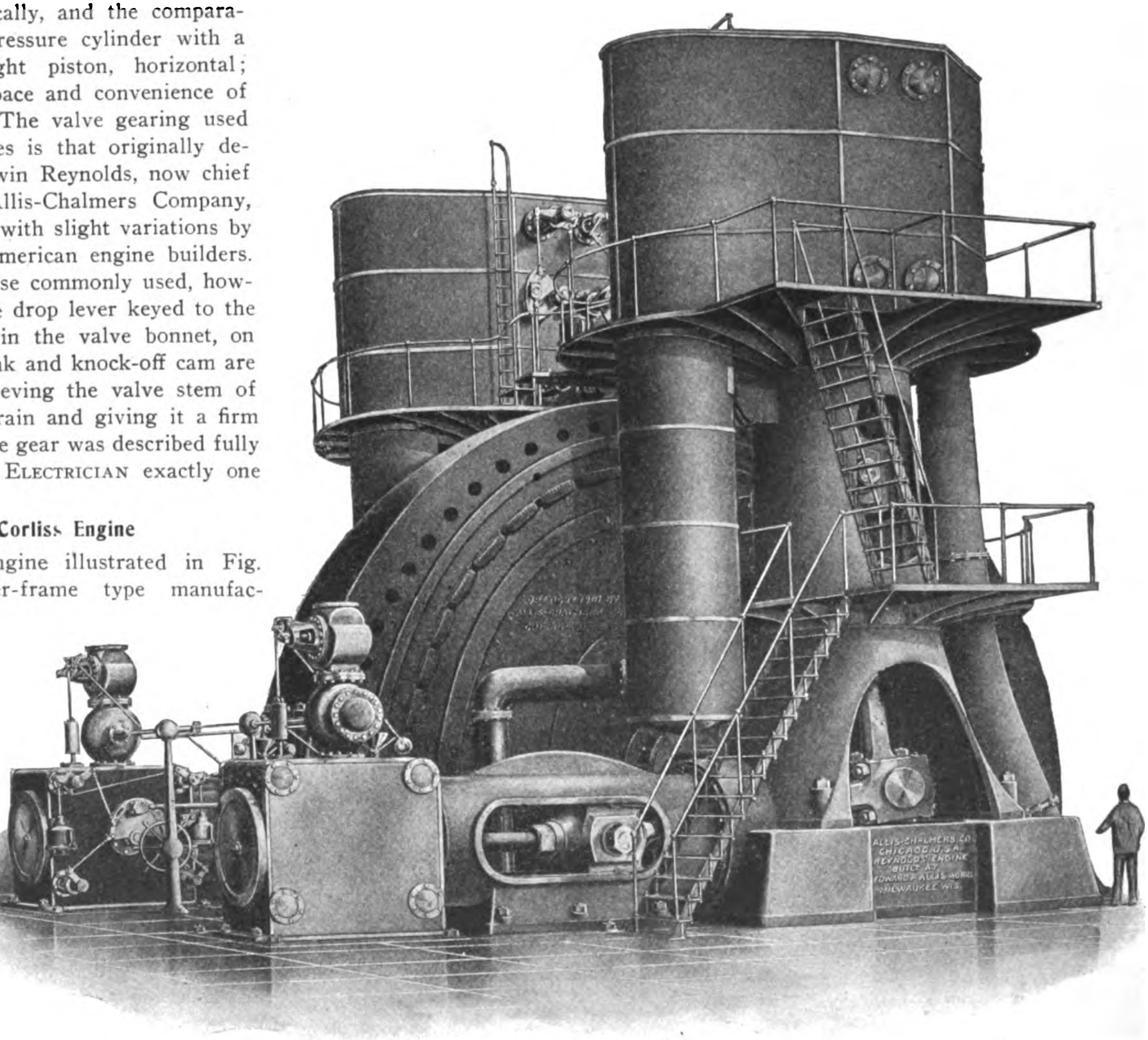


FIG. 3.—REYNOLDS COMBINED VERTICAL AND HORIZONTAL DIRECT-COUPLED ENGINE.

Both the steam and exhaust valves are of the double-ported type operated from a common wrist-plate in the single-eccentric type and from separate eccentrics in the "long range" style, in the usual manner. The valve rods are adjustable to take up wear, and the releasing gear is of the over bell-crank form with the drop lever on the same side as the valve rods; the bell-cranks and knock-off cams are mounted on extensions of the valve bonnets.

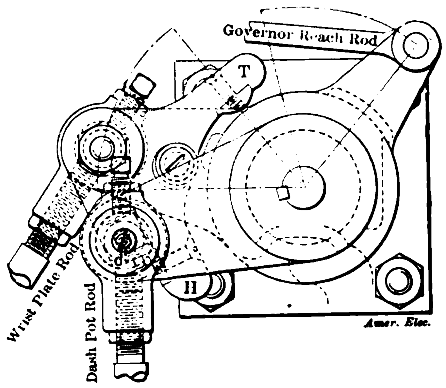


FIG. 5.—ATLAS RELEASING GEAR.

A patent grab-hook working without the use of springs is used, as shown in Fig. 5, inertia, centrifugal force and the force of gravity are relied upon to operate the hook. The hook, *H*, and trip, *I*, are made comparatively massive, and the weight is so distributed that when the hook is down ready to engage with the die, *d*, on the drop lever, the kinetic reactions of the lever on reversal of the direction of motion, centrifugal force and gravity (due to the position of the center of gravity of the grab-hook not being in a perpendicular through the pivot) throw the grab-hook outward positively, even at the highest speeds. Release of the drop lever is effected by means of the usual knock-off cam operated by the governor. A vacuum dash-pot of the differential type bolted to the cylinder feet and sunk below the floor closes the valves.

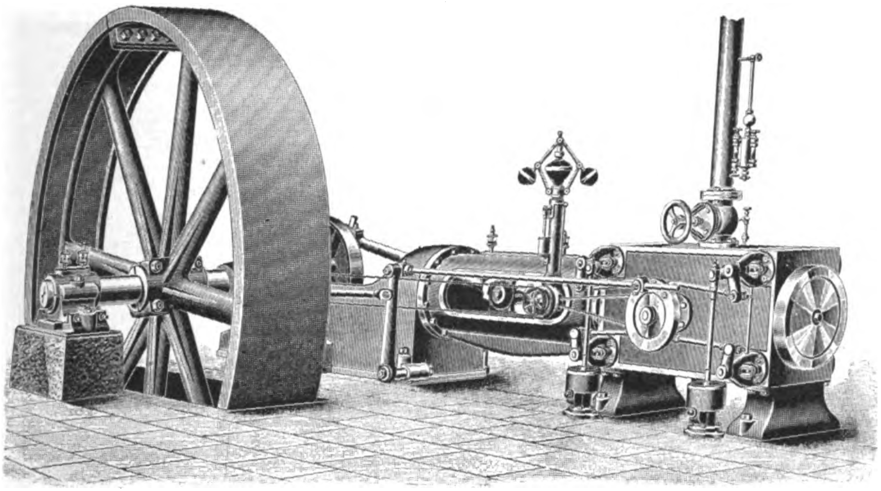


FIG. 6.—BATES CORLISS ENGINE.

A belted governor of the weighted fly ball design, with an automatic safety stop preventing accident in case of the belt breaking, is attached to the frame, having bevel gears enclosed and running in oil. A hollow piston with two stiffening ribs is used, held on the piston rod by a flush nut.

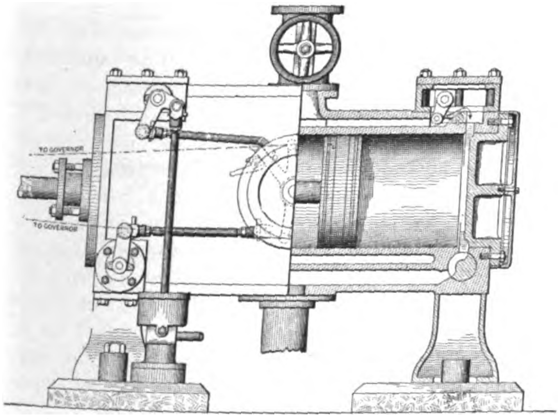


FIG. 7.—SECTIONAL VIEW OF BATES FLAT SLIDE VALVE.

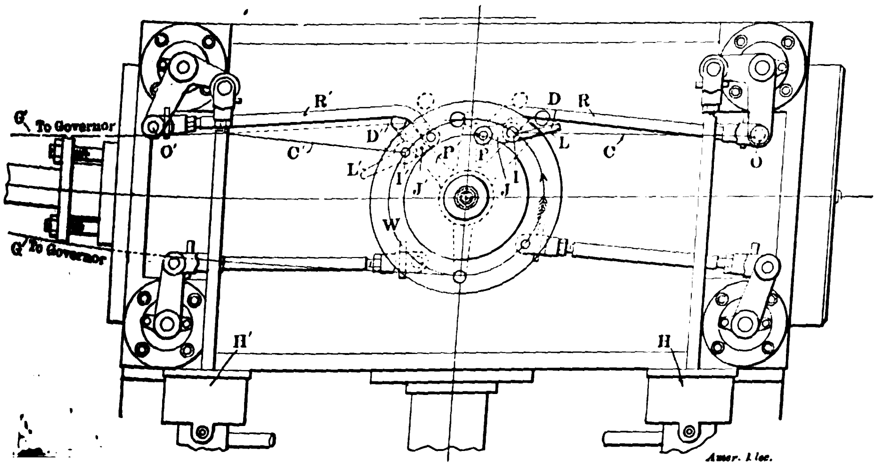


FIG. 8.—BATES RELEASING BUT NON-DETACHING GEAR.

A recess in each side of the piston to clear the ports permits the use of small clearance and gives a free entrance for the incoming steam. The cross-head is of the box type and differs from those on most engines of this class in having flat wearing surfaces in place of the V grooved, or bored as is the general practice.

Bates Corliss Engines.

A variety of box girder and heavy duty frame engines of the simple, tandem and cross-compound types are built by the Bates Machine Company, Joliet, Ill., fitted with non-detachable valve releasing mechanism. A general idea of the appearance of these engines will be gained by examining Fig. 6. The cylinders are shown in Figs. 7 and 7A, which show the slide and rocking type of steam valves employed. In Fig. 7a it will be noticed that the steam valve, which is of the single-ported variety, has a central opening, and when in the open position, as shown, covers the valve seat, preventing the wearing of grooves. This same principle is applied to the flat steam valves, which have the advantage that should they become worn they can be scraped to a steam-tight fit in a few hours, and are, therefore, desirable in places remote from machine shops.

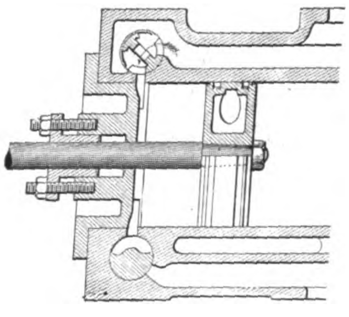


FIG. 7A.—CYLINDER OF BATES ENGINE.

As seen from the illustrations, the exhaust valves are of the standard single-ported design. Both the rocking steam and exhaust valves are driven by T heads, and are arranged so that they can be removed for examination and repairs without disturbing the valve gear. The operation of the valve gear, shown in Fig. 8, is as follows: The admission valve stems carry bell cranks, to one lever of which the dash-pot is connected, the other connecting with the wrist plate through the rods *R*. The arms, *D D*, are pivoted on the same pin as the wrist plate, but independently, and are separately connected to the governor, their position defining the point of release. As the wrist plate moves in the direction of the arrow from the position shown in the engraving, the link, *J'*, will fold under the valve rod, *R'*, until the center of the pin, *P'*, falls below the line of pull, *C'*. Then as the wrist-plate moves in the opposite direction, the rod, *R'*, will be pulled with it, opening the valve until the end of the lever, *L'*, engages with the pin in the end of the *D'*, which, by stopping the further movement of the lever, will unfold the knuckle formed by the arm *J'* and the valve *R'*, allowing the dash-pot to pull the rod, *R'*, to the left and close the valve.

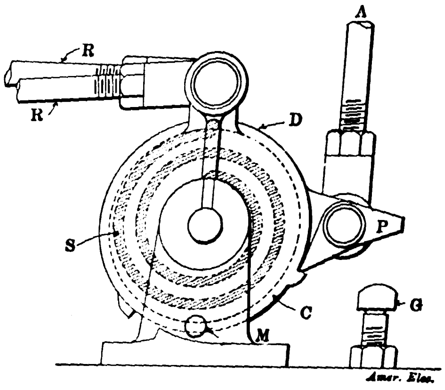


FIG. 9.—BATES SAFETY STOP.

The governor, which is of the ordinary fly ball type, is supplemented by the automatic stop shown in Fig. 9, in which *C* is a case containing a spring *S*, one end of which is attached to the rim of the case and the other end to the hub of the disc, *D*. The movement of the case, *C*, is normally controlled by the governor through the rod *A*, carrying the pawl, *P*. Should the governor for any reason fall abnormally low, the pawl *P* would strike the adjustable screw, *G*, causing the pawl to release the case, *C*, and the disc, *D*, which would be rotated in opposite directions by the spring inside so as to throw the levers to the positions which prevent the valves from opening. As the engine is shut down the engineer pushes the pin, *M*, into a recess in the disc, *D*, thus holding up the governor balls at such a height that the pawl, *P*, cannot come in contact with the screw, *G*.

A box type of cross-head reciprocating in *V* guides is used, as indicated by Fig. 10, which also illustrated the method of holding the cross-head pin, which must be removable because of the solid-end type of connecting rod used. A modified stub end is used at the crank-pin end. The main bearing brasses are made in four sections, the two receiving the thrust of the connecting rod being adjustable by wedges which tighten by screwing upward, preventing accidental jointing. Fly-wheels made in halves are used, machined to a fit and bolted to the shaft at the hub and rim, besides which they are further reinforced at the hub by shrinking on four steel loops.

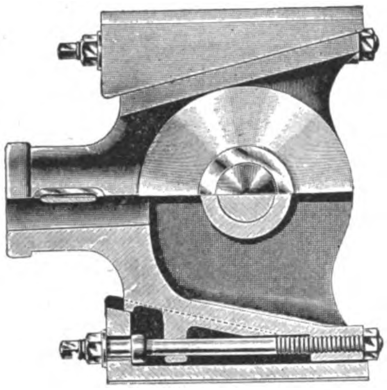


FIG. 10.—BATES CROSS-HEAD.

Brown Corliss Engine.

A tandem compound engine made by the Brown Corliss Engine Company, Corliss, Wis., is shown in Fig. 13, from which it is evident that the frame is of the heavy duty box type, cast in one piece with the main bearing pillow-block, and supported on the foundation throughout its entire length. It will also be seen that the long range cut-off gear is employed, with skeleton wrist plates, but in engines intended for speeds of 120 to 150 r.p.m. the wrist plates are omitted, the steam valves being driven by an eccentric motion, and the exhaust valves by a wrist plate motion obtained by the usual bell-crank method. Many of the important details of the cylinder are shown in Fig. 14, the most noticeable being the location of the exhaust valves, which are placed partly within the cylinder, and so formed as to reduce the clearance to a small amount.

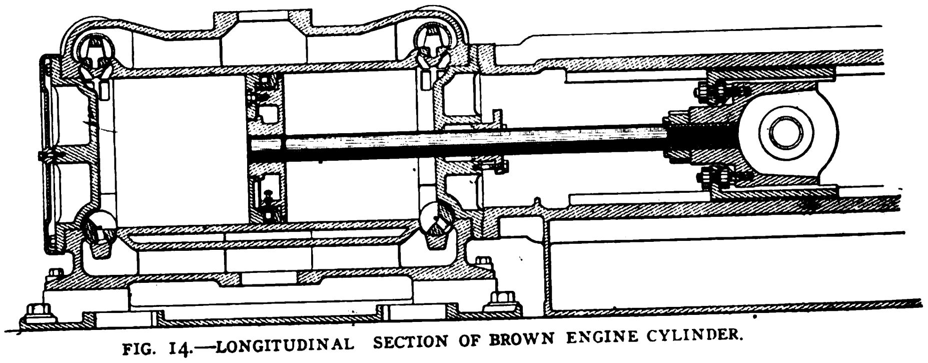


FIG. 14.—LONGITUDINAL SECTION OF BROWN ENGINE CYLINDER.

Double-ported valves are used for both steam and exhaust; the steam valves open against the steam (that is, the valve seat is covered by the valve, preventing the seat being "cut" by water entrained in the steam) having openings through the center to permit the steam to pass. The exhaust valves, it will be noted, are supported directly under their center line, reducing the possibility of bending and the consequent uneven wear. In Fig. 12 it will be seen that the drop lever is supported on the valve spindle within the bonnet, upon which the knock-off cam and bell crank are mounted. Fig. 11 gives the front view of the releasing gear. The latch block, *B*, is held on a short lever keyed to a short shaft, *S*, having the trip lever, *D*, keyed on its other end, the whole being mounted on the bell-crank lever which receives its motion from the valve rod, *A*. When the point of release is reached, the trip lever is thrown outward by the block, *E*, on the knock-off cam controlled by the governor, releasing the drop lever, *C*, which is then drawn down, closing the valves. The safety block, *F*, will be rotated into a position which will prevent the opening of the valves, should the governor belt slip or break. A novelty in the governor construction is that the levers connecting the balls to the center weight are not pivoted at the centers of the balls, but further out towards the edge; this increases the sensitiveness of the governor.

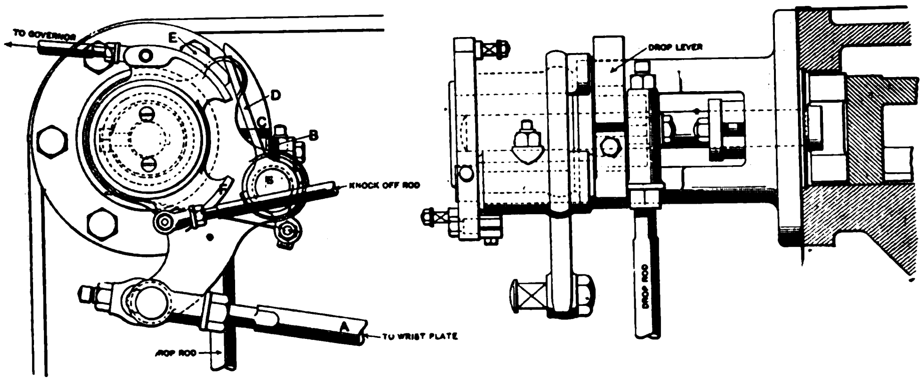


FIG. 11.—BROWN RELEASING GEAR—FIG. 12.

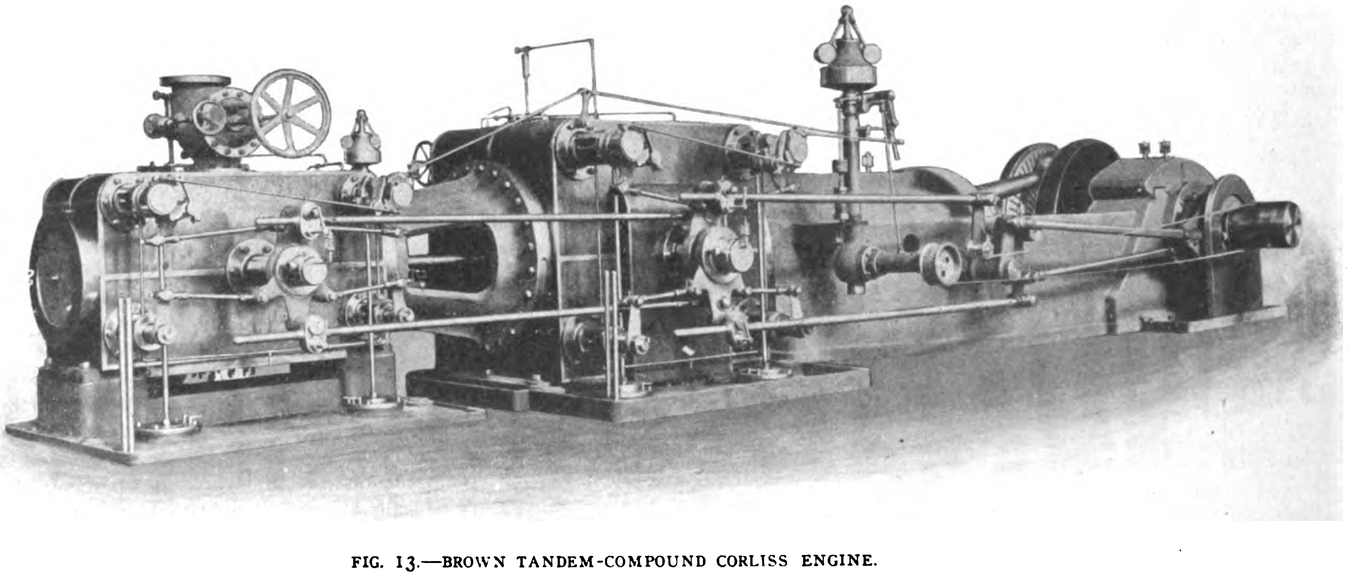


FIG. 13.—BROWN TANDEM-COMPOUND CORLISS ENGINE.

Cooper Corliss Engines.

Figs. 19 and 16 show general views of a heavy duty cross-compound direct-connected engine, and the high-pressure cylinder of a heavy duty cross-compound, fitted with the long range cut-off gear, as manufactured by the C. & G. Cooper Company, Mount Vernon, Ohio. This company also builds the ordinary girder frame Corliss engine that has been the standard for engines of moderate power for some years. The valve gear used on the smaller engines is of the under-type bell-crank construction, but otherwise the same as that used on the heavy duty type to be described later. Though the illustrations only show examples of the cross-compound engines, the manufacturers also make a full line of simple, tandem and twin tandem compound engines for direct connection to electric generators.

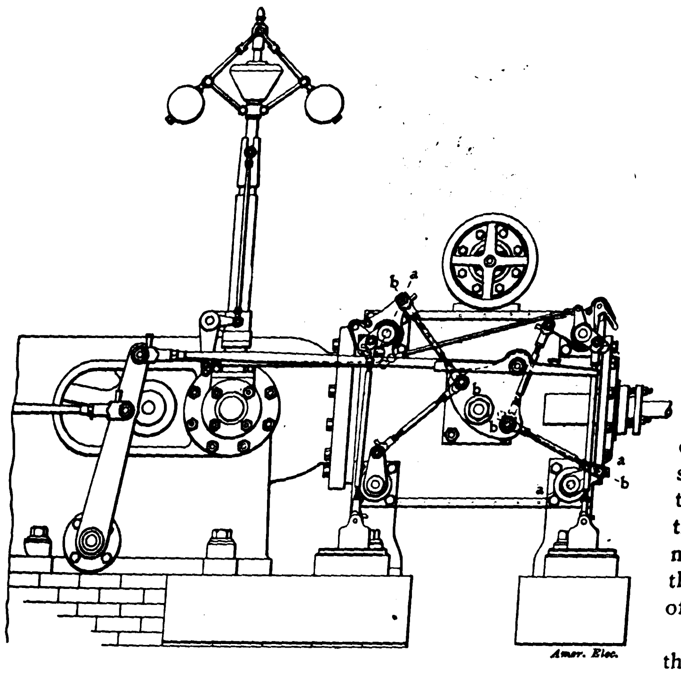


FIG. 15.—COOPER VALVE GEAR.

The valves of the Cooper engines are single-ported and of the skeleton type, driven by a T-connection on the valve spindles, permitting the valves to adjust themselves for wear. Fig. 16 shows the long-range cut-off valve gear, showing the use of two rocker plates and the over-type bell-crank valve-gear, which gives the quickest opening of the steam valves. A simple unhooking device is fitted to the wrist plate rods for hand starting, should the engine have stopped with the piston part cut-off in the high-pressure cylinder. The releasing gear is of the modified Reynolds design, illustrated in Fig. 15, which shows a unique feature in that the valve rods of the steam and exhaust valves are both operated from a common wrist pin.

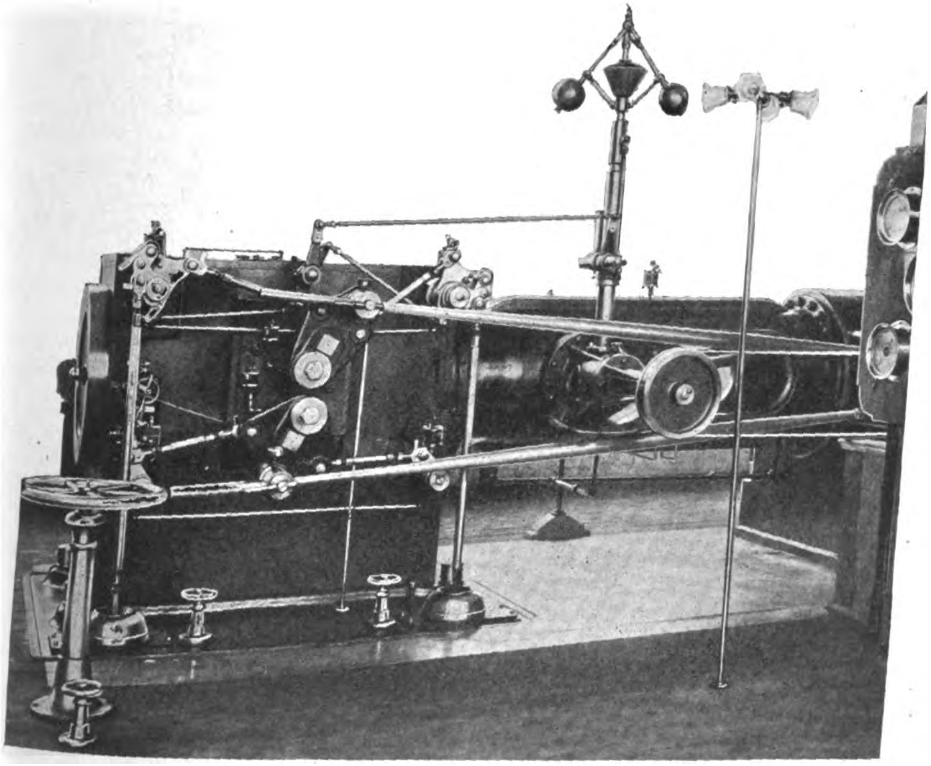


FIG. 16.—VALVE GEAR OF COOPER CORLISS ENGINE.

By noting the angle between the center lines, *aa* and *bb*, it will be evident that the gear gives a quick opening of the steam valve and quick closing for the exhaust, which has full port opening almost up to the closure of the valve. The steam valves are closed as usual by vacuum dash-pots bolted to the cylinder feet. All the valve rods have adjustable end quarter boxes for setting the valves and taking up wear, and the reach rod has means for equalizing the cut-off at both ends of the cylinder.

Fig. 15 also shows the governor, which is of the Porter weighted pattern, equipped with a dash-pot to prevent oscillation or hunting by the governor, and a safety stop to prevent accident should the governor belt slip or break. The bearings are the familiar hexagon quartered type, adjustable by screws and wedges in a fore-and-aft direction, preventing the shaft from gradually being moved towards the cylinder and thus changing the clearance. This, as well as the construction of the eccentric and connecting rod, will be seen by examining Fig. 15.

Filer & Stowell Engine.

The heavy duty engine shown in Fig. 21 represents the "1900" type built by The Filer & Stowell Company, Milwaukee, Wis. As is shown in the illustration, the whole frame is cast in one piece resting on the foundation along its entire length, thus giving solid support to the guides and main bearing. Besides this, the same firm make what they have termed their "Standard" frame, which is a heavy duty design of the ordinary style made a trifle lighter than the "1900" form. A section through one of the cylinders is shown in Fig. 17, which indicates clearly its construction, as well as that of the double-ported steam and exhaust valves; the construction of both valves is such that quick opening and closing of the ports are secured with a relatively short travel. The releasing gear is in many respects similar to the standard Corliss gear, and its operation will be readily understood by reference to Fig. 18, in which *B* is the bell crank carrying the hook, *H*, mounted

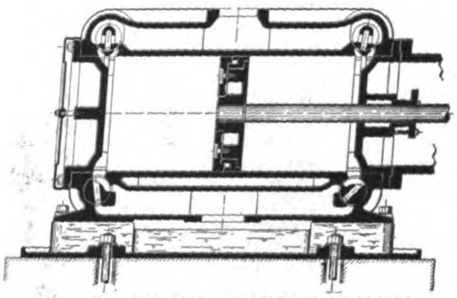


FIG. 17.—SECTION OF FILER & STOWELL CYLINDER.

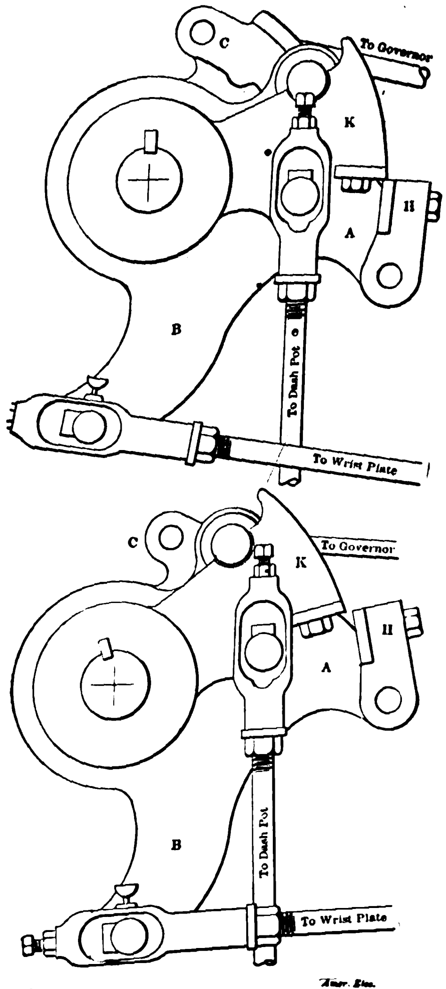


FIG. 18.—FILER & STOWELL RELEASING GEAR.

on the end of a short shaft, on the other end of which is the trip lever which engages with the knock-off cam, *C*, controlled by the governor in the usual way through the reach rod. A governor of the weighted Porter type is used.

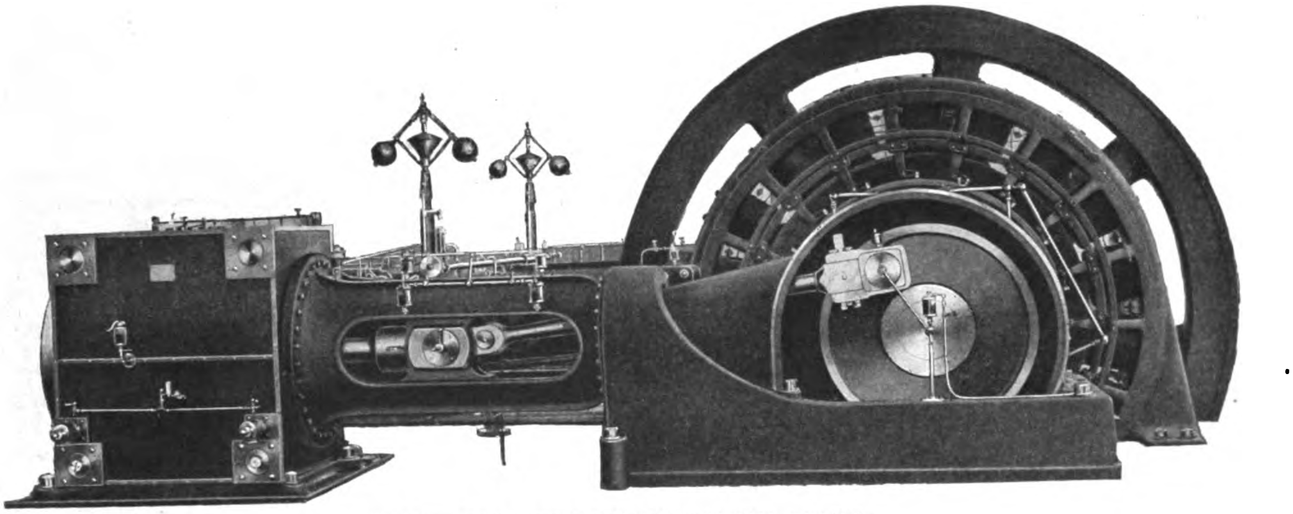


FIG. 19.—COOPER CROSS-COMPOUND CORLISS ENGINE.

The solid-end connecting rods used on these engines are different from the ordinary form in having the adjusting wedges with a side instead of an end taper, which has the advantage of permitting the brasses to be supported over their whole area. Flywheels made in four sections with square rims of the design shown in Fig. 20 are put on all engines intended for direct connection to electric generators. Referring to the illustration, it will be seen that the hub is finished separately from the arms; it is pressed on the shaft by hydraulic pressure. Five bolts secure each section to the hub, the rims being held together by bolts and steel arrow heads.

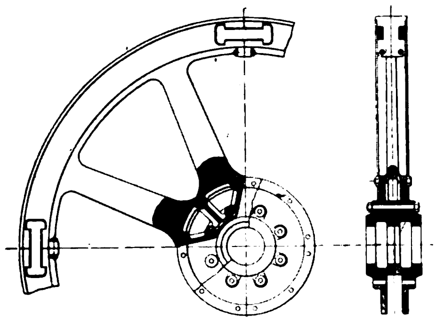


FIG. 20.—SECTION OF FILER & STOWELL FLY-WHEEL.

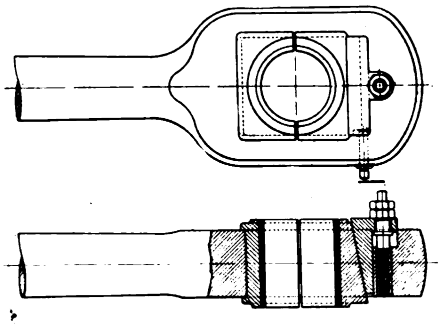


FIG. 22.—FILER & STOWELL CONNECTING ROD.

Fishkill Corliss Engine.

Fig. 24 represents a rear view of a long-range cut-off tandem compound engine built by the Fishkill Landing Machine Company, Fishkill-on-Hudson, N. Y. A girder frame is used, with a support under the ends of the guides, which are V-shaped. Ordinary wrist-plates are used on the single eccentric engines, but the skeleton form is used on the two-eccentric type because the pins and rod ends are more easily accessible. All valve and drop rods can be lengthened or shortened at will, and wear can be taken up by screw adjustment of the quarter boxes.

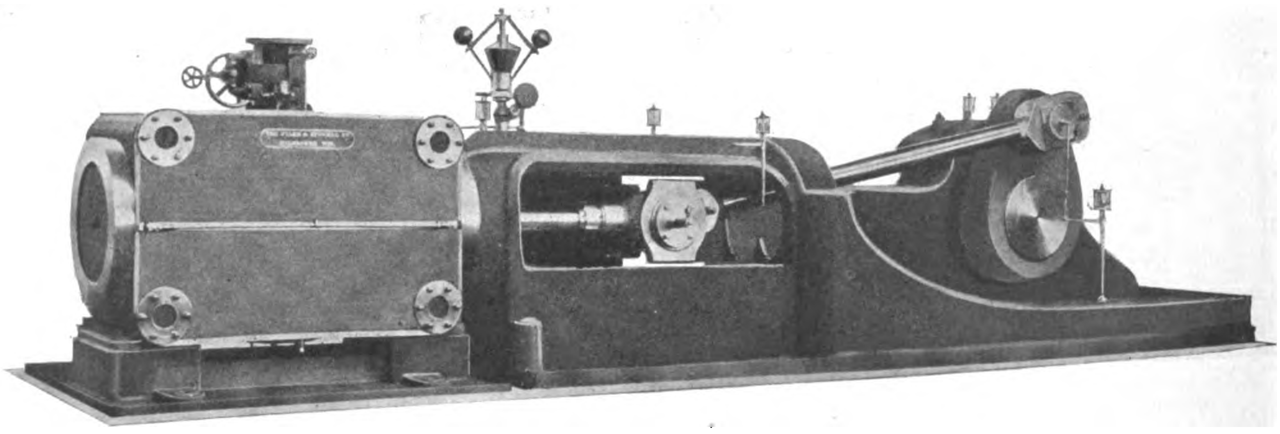


FIG. 21.—FILER & STOWELL HEAVY DUTY CORLISS ENGINE.

Cité's releasing gear shown by Fig. 23 is used; it differs from the ordinary Corliss releasing gear in the form of knock-off mechanism. In the place of the usual knock-off cam, there is a ring having three arms, one of which, *H*, is connected to the governor by the reach rod, *Z*. Of the other two, the arm, *j*, carries a roller at its end, and the third a cam, *W*, which is adjustable and takes the place of the usual safety block on the knock-off cam. The gear is shown in its upward movement, the grab-hook, *E*, being engaged with the drop lever, *c*. As the grab-hook moves upward, the roller, *R'*, comes into contact with the rol-

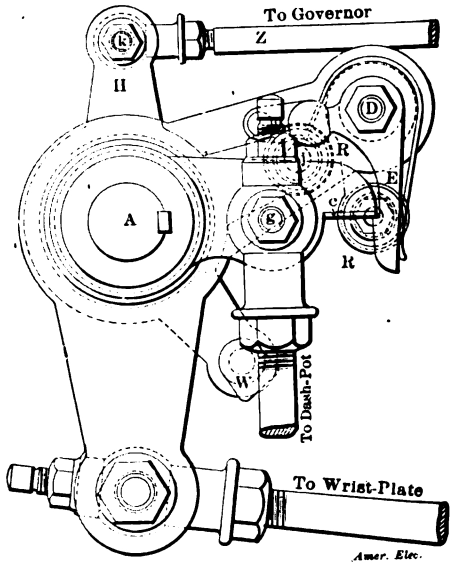


FIG. 23.—FISHKILL RELEASING GEAR.

ler, *R*, which forces *R'* outward, and thus releases the drop lever, which is then moved down by the dash-pot as usual. The dash-pot is of the differential type operated by compressing air within it as well as by vacuum. As no air escapes into the engine-room, it is noiseless in its operation.

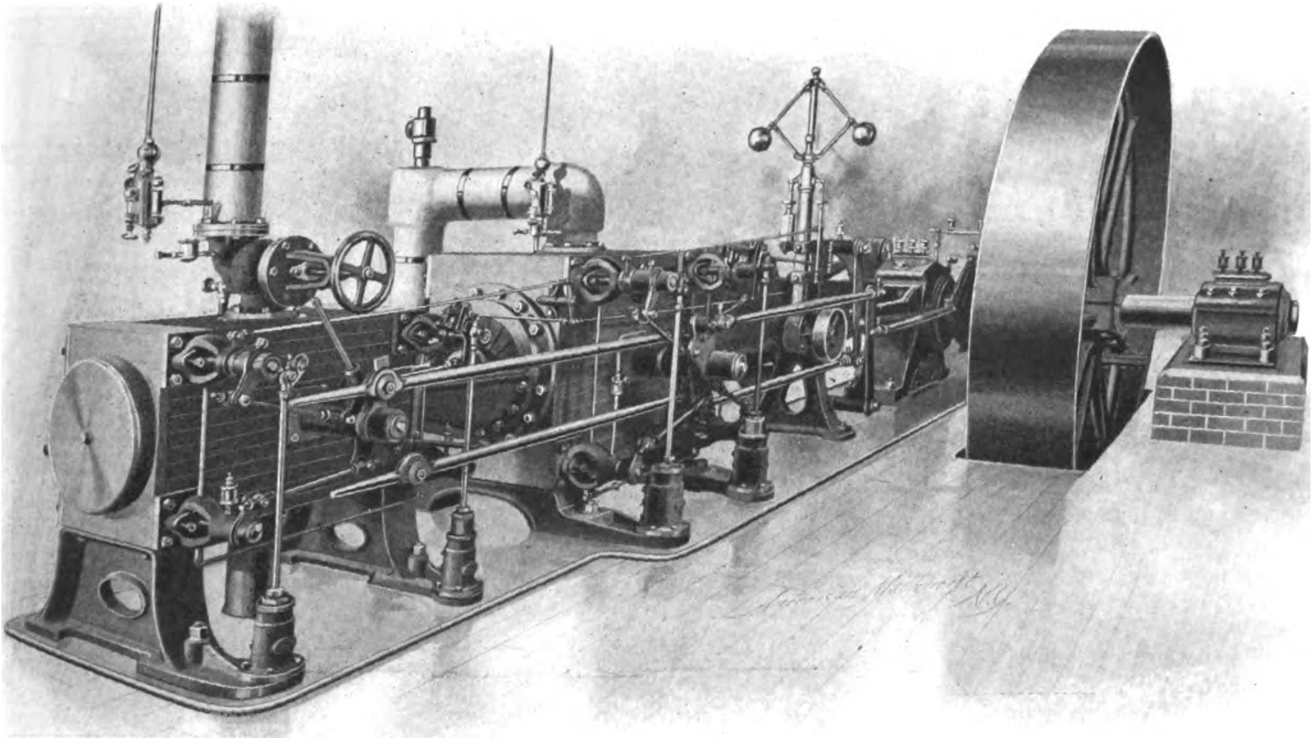


FIG. 24.—FISHKILL TANDEM-COMPOUND CORLISS ENGINE.

A hollow piston strengthened with ribs is used, as shown in Fig. 26, which illustrates the method of centering the bull ring and of attaching it to the piston rod. The box cross-head used differs from the usual construction in having the shoes adjustable by means of keys with screws set through the cross-head, thus taking up the wear without moving the slippers. It is attached to the rod by a cross key.

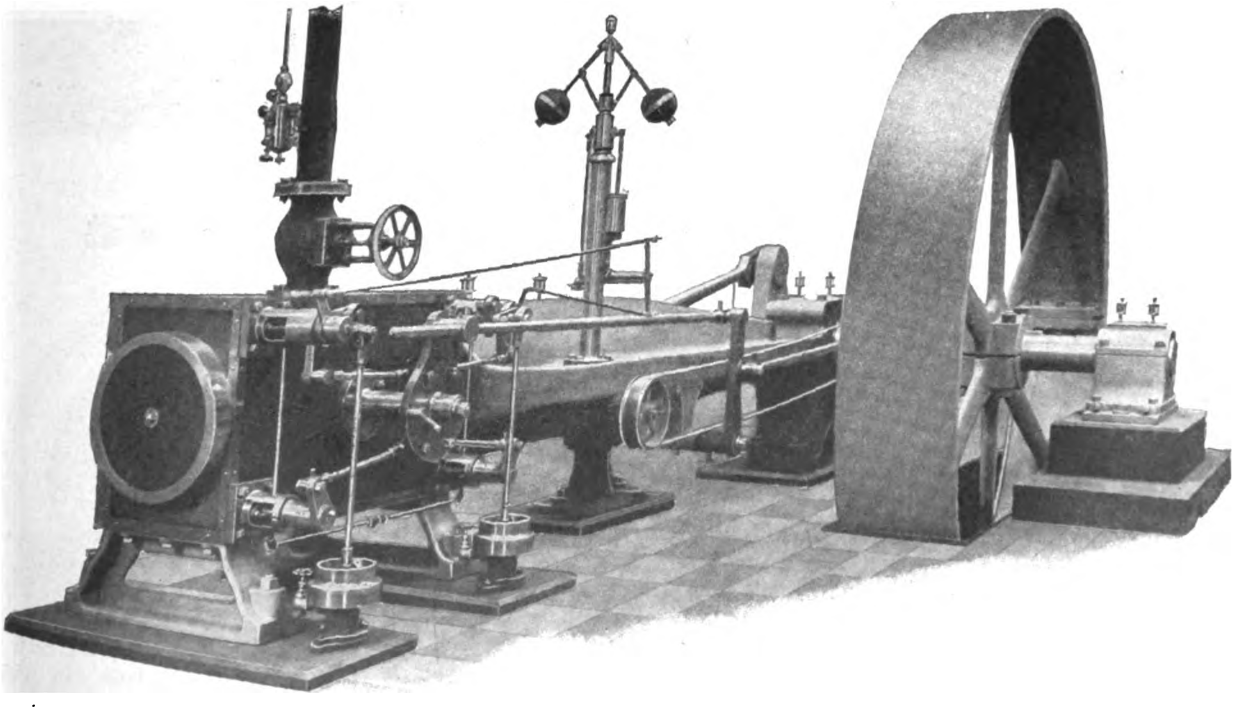


FIG. 25.—HAMILTON CORLISS ENGINE, STANDARD GIRDER FRAME.

Hamilton Corliss Engine.

One of the types of engine manufactured by the Hooven-Owens-Rentschler Company, Hamilton, Ohio, is shown in Fig. 25, which illustrates the Hamilton-Corliss girder frame short-range cut-off engine. These engines are also made in the cross-compound and tandem types, fitted with the long-range cut-off gear, having the double wrist plate arrangement shown in Fig. 2. Single-ported valves are employed, giving a full opening and a small clearance. The valves which are of the skeleton type are driven by a T-head in the usual manner, permitting self-adjustment for wear. The standard Corliss gear, as employed on most engines of this class, is used. It is made light and strong, all the valve rods having quarter boxes adjustable by keys to take up wear and keep the valves properly set, and the reach rod has also the usual arrangement to equalize the cut-off. Releasing gear of the Reynolds type is employed, having reversible latch blocks mounted on bronze grab-hooks.

The piston, which is of the hollow design usually employed on stationary engines, is made as light as consistent with strength and has numerous stiffening ribs; the back being made up of the follower plate allows the piston packing, which is of the Harris sectional ring pattern, to be removed without removing the piston from the cylinder. The piston used on the Hamilton Standard and "Series B" types is shown in Fig. 27. The rod is turned at the end to a taper and forced into the piston against a shoulder and secured by a key. A box type of cross-head with adjusting wedge is used, attached to the rod by a key and cotter pin; this method insuring that the designed length of rod shall always be maintained and in this way avoiding the possibility of incorrect setting with the consequent danger of knocks through unequal clearance. It has adjustable shoes riding in V-grooves, which prevent the piston from turning and thus throwing extra strain on the crank and wrist pins.

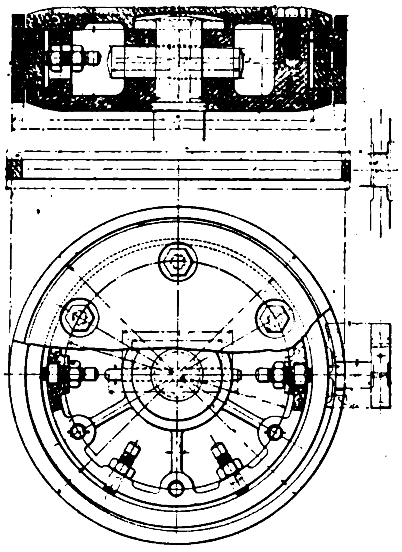


FIG. 26.—FISHKILL HOLLOW PISTON.

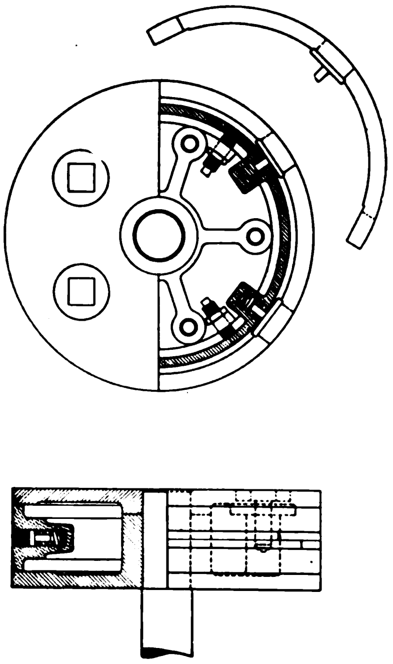


FIG. 27.—HAMILTON PISTON AND PACKING.

The main bearings are made with compensating quarter boxes, which take up the wear and keep the shaft at the proper distance from the cylinder. Phosphor-babbitt is cast and hammered into the main bearings, after which they are bored out to the finished size. The connecting rods of the Hamilton engines are made with solid ends, with adjustable babbitt-lined brasses, moved by an in-and-out wedge, keeping the distance between the centers constant. Fly-wheels of 18 feet diameter and under are made in halves bolted together, are turned on the face and sides and are fitted with internal stiffening rims.

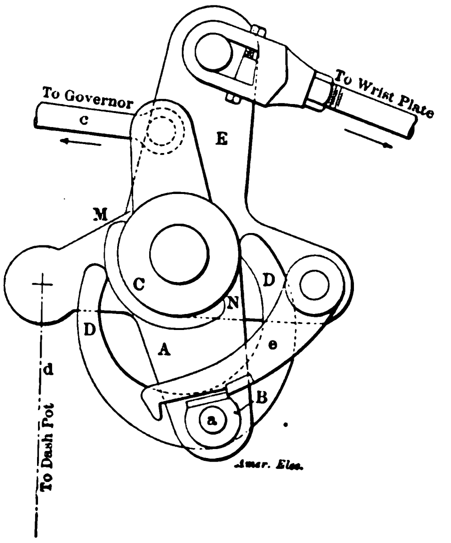


FIG. 28.—HARRIS RELEASING GEAR.

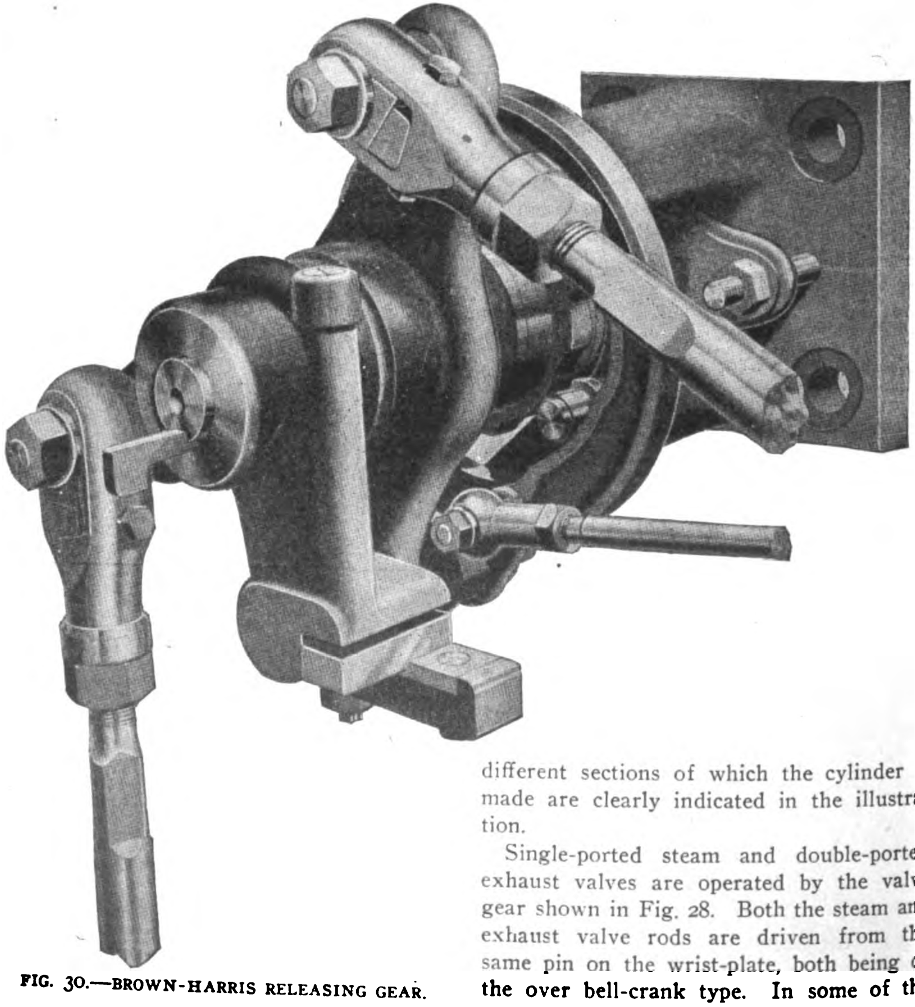


FIG. 30.—BROWN-HARRIS RELEASING GEAR.

Harris Corliss Engines.

Long and short-range cut-off engines of the girder type are made by the Wm. A. Harris Steam Engine Company, Providence, R. I., Fig. 25, being similar to the latter class. An "I" section is used for the frame, with the web horizontal; the guides, which are of the V pattern, and the pillow-block form one casting. An interesting example of cylinder construction is given in Fig. 29, showing the Harris jacketed sectional cylinder. It is so arranged that the barrel is free to expand and contract independent of the rest of the cylinder, the joint being made tight by a fibrous packing. The different sections of which the cylinder is made are clearly indicated in the illustration.

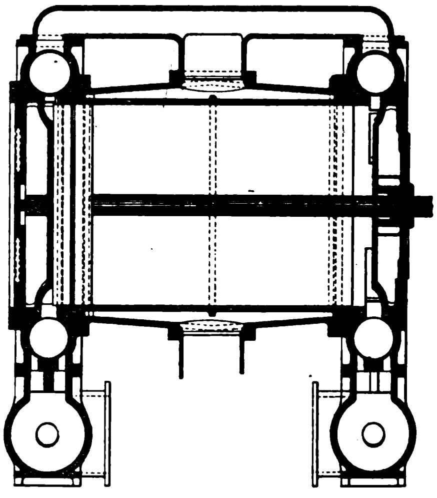


FIG. 29.—HARRIS JACKETED SECTIONAL CYLINDER.

Single-ported steam and double-ported exhaust valves are operated by the valve gear shown in Fig. 28. Both the steam and exhaust valve rods are driven from the same pin on the wrist-plate, both being of the over bell-crank type. In some of the tandem compound engines, the long-range cut-off gear is fitted to the low-pressure cylinder only. The well-known Brown releasing gear shown in Figs. 30 and 31 is employed. The lever, *A A*, carries the shaft, *a*, to one end of which is keyed the grab-hook, *D*, and to the other end the trip lever carrying the roller. *E*, which slides in the groove of the knock-off cam, *K*. The drop lever, *B B*, carries a moveable die, *C*, suspended on a bolt, thus allowing it to rise as the hook *D* passes backward under it.

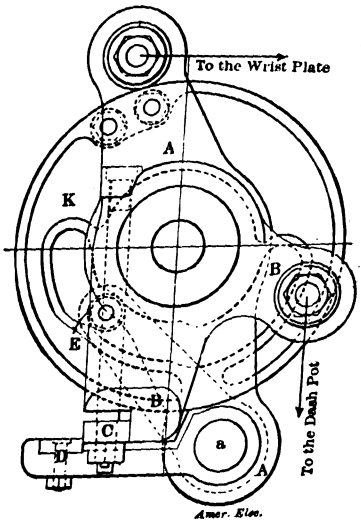


FIG. 31.—BROWN-HARRIS RELEASING GEAR.

As the lever, *A*, moves in the direction indicated, the valve is opened and remains so until the roller, *E*, is thrown downward by the cam slot disengaging the grab-hook, *D*, and releasing the valve. The cam is so constructed that should the spread of the governor become abnormally low, or the governor belt break, the hook, *D*, would fail to engage with *C*, as is the case in all releasing gears.

Lane & Bodley Engines.

The Lane & Bodley Company, Cincinnati, Ohio, manufactures an extensive line of simple and multiple expansion engine of the girder-frame and heavy duty type. Fig. 32 shows a single cylinder engine of the standard heavy duty type. The simplicity of the valve-gear, absence of wrist-plates, and the use of dash-pots bolted directly to the cylinder are notable features of the design. Hollow pistons, box cross-heads running in bored guides and solid-end connecting rods of the familiar pattern are used. The steam and exhaust valves are double-ported and driven by T heads. Slight changes have been made from the usual Corliss releasing mechanism, which will be noted by reference to Fig. 34. The grab-hook works on the outside of the drop rod stud, and the drop lever is placed inside the bonnet on which the bell crank and knock off cams are mounted. Further it may be observed that the small light valves, short drop rods, light dash-pot plungers and the absence of wrist plates make it possible to operate this gear at high speeds.

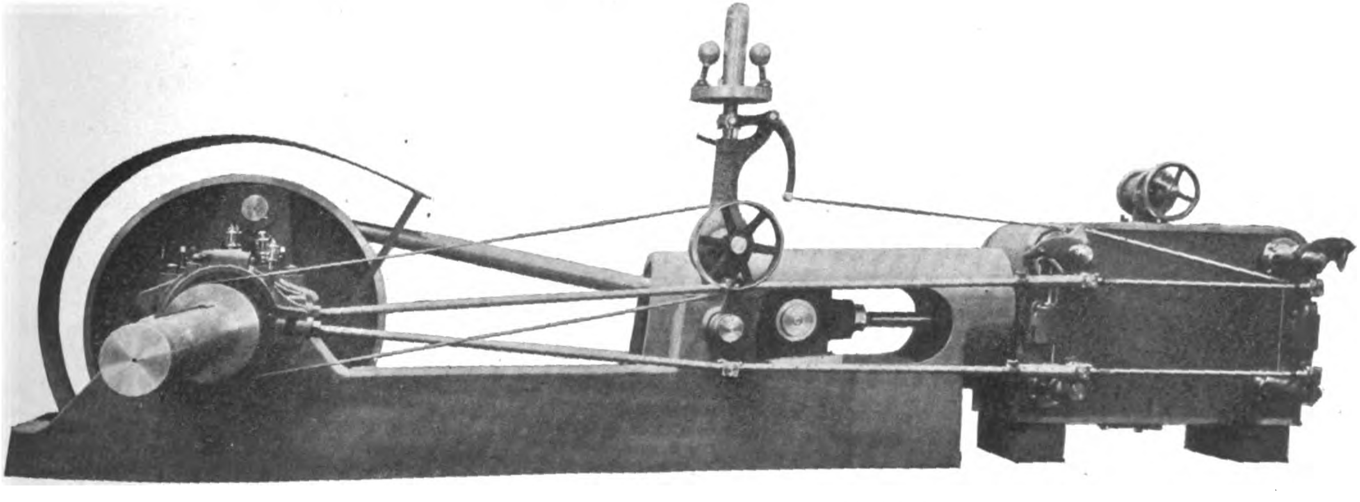


FIG. 32.—LANE & BODLEY 20TH CENTURY CORLISS ENGINE.

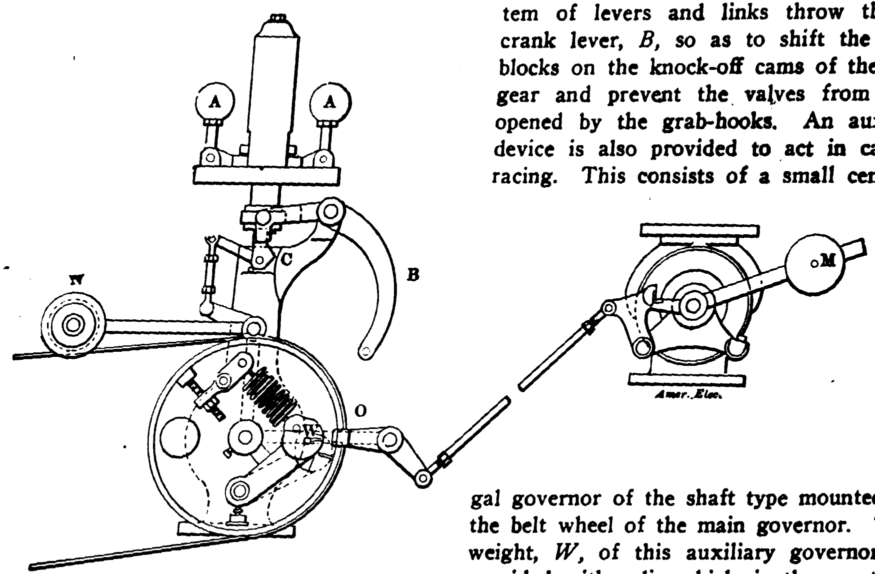


FIG. 33.—LANE & BODLEY GOVERNOR.

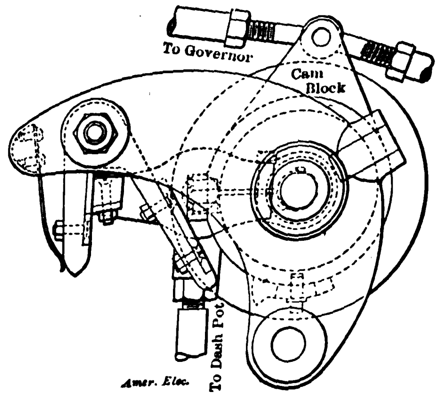


FIG. 34.—LANE & BODLEY RELEASING GEAR.

A safety device is fitted to the governor which is shown assembled with it in Fig. 33. The balls, *A A*, are attached to the vertical arms of a pair of bell cranks, and the other ends engage in the usual manner with a grooved collar on the end of a sleeve on the valve spindle. The other end of the sleeve carries another collar which engages the inner end of the bell crank lever, *B*. The curved arm of this lever is connected to the knock-off cams of the valve gear by reach rods. If the governor belt breaks the weight, *N*, will drop, and through the system of levers and links throw the bell crank lever, *B*, so as to shift the safety blocks on the knock-off cams of the valve gear and prevent the valves from being opened by the grab-hooks. An auxiliary device is also provided to act in case of racing. This consists of a small centrifugal governor of the shaft type mounted in the belt wheel of the main governor. The weight, *W*, of this auxiliary governor is provided with a lip which, in the event of abnormal speed, will be thrown outward so as to engage with the small lip, *O*, on the end of the rocker arm shown. The other end of the rocker arm is connected to a latch which normally holds the throttle open. When the lip on the governor weight, *W*, engages the projection, *O*, this latch is thrown, allowing the weight, *M*, to close the throttle.

Murray Corliss Engine.

A light, but strong construction for a girder type of frame is that shown in Fig. 35, which illustrates the box girder frame of the Murray Iron Works Company, Burlington, Iowa. This type of frame is used on engines from 18 ins. x 42 ins. upward, the ordinary form of girder frame being used on engines of the smaller sizes, while the larger engines and those for extra hard service are of a new and special heavy duty design, shown in Fig. 36. As will be seen, this style of heavy duty frame differs from the usual practice in that additional support is given to the guide by a box construction resting on the foundation. The cylinders are constructed with the exhaust passage separated from the cylinder by an air space which prevents the heat in the cylinder from escaping to the exhaust through the cylinder walls, and also prevents any local strains which may be set up in the cylinder casting when this is not done.

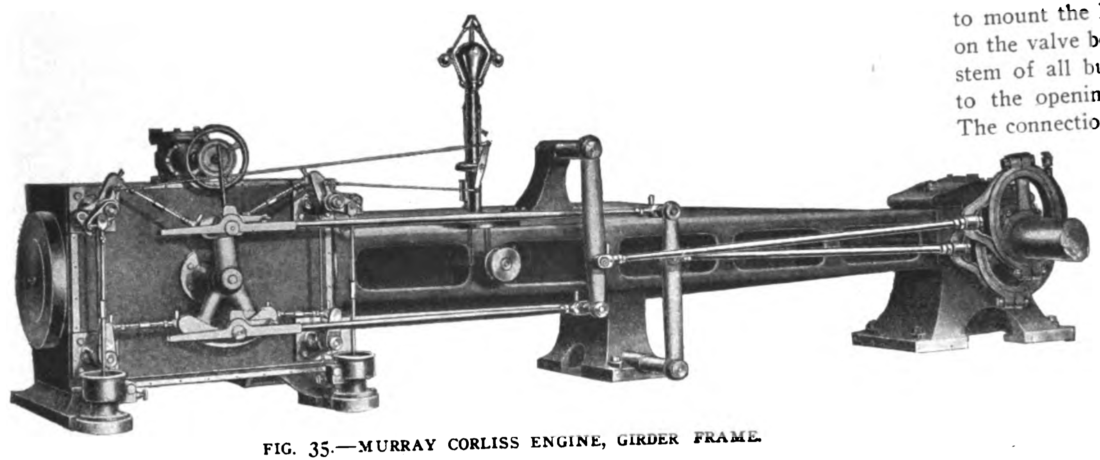


FIG. 35.—MURRAY CORLISS ENGINE, GIRDER FRAME.

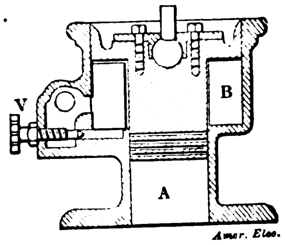


FIG. 38.—DASH POT.

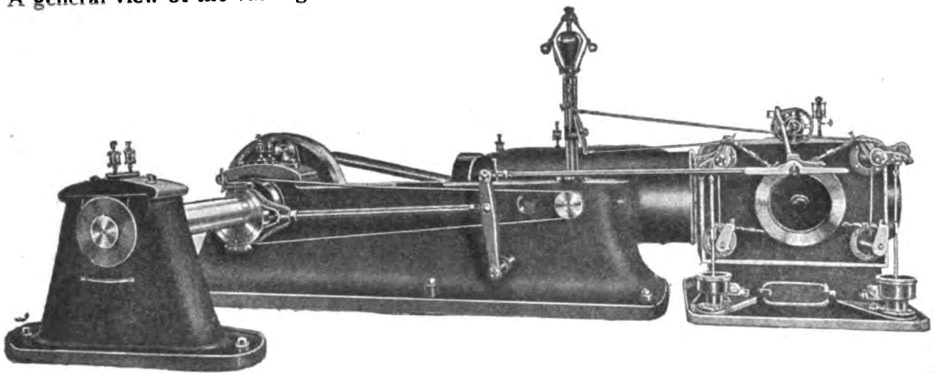


FIG. 36.—MURRAY HEAVY DUTY CORLISS ENGINE.

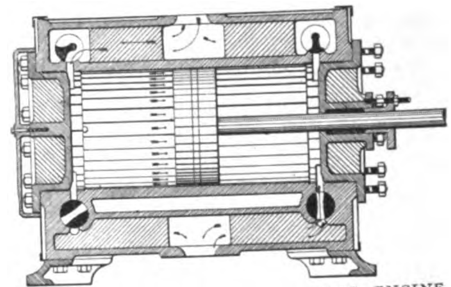


FIG. 39.—CYLINDER OF MURRAY CORLISS ENGINE

A general view of the valve gear is shown in Figs. 35 and 36, the former showing the long range, and the latter the short range type. In the short-range type the ordinary wrist plate construction is used, but in the long-range gear a lever construction is used, thus avoiding the unnecessary metal and making it easier to get at the pins and adjusting blocks for taking up wear. The valves are clearly shown in Fig. 39, which illustrates the type of valve generally provided; the steam valves, as will be noted, are of the skeleton type, and the exhaust of the solid type. The valves are driven by a T-head, which gives them freedom to adjust themselves for wear, the special feature of the exhaust valves being that inasmuch as they are made solid the clearance is much reduced and a greater surface is exposed for wear. Fig. 41 shows the form of double-ported valves used on Murray special engines and those of great size. These valves give a quick and ample opening to steam and exhaust, as well as a sharp cut-off and compression. The releasing gear is shown in Fig. 37, which shows the drop lever to be outermost, making it convenient to mount the knock-off cam and bell crank on the valve bonnet, thus relieving the valve stem of all but the unavoidable strain due to the opening and closing of the valve. The connection to the wrist plate, as shown, is of the over-type bell-crank construction, giving a very sharp valve opening, while a sharp cut-off is insured by a simple noiseless dash-pot of the double-chamber vacuum type shown in Fig. 38. The governor which is of the weighted Porter type, has the upper portion of the central weight cast hollow, into which space shot can be placed, adjusting the speed in this manner to any desired degree of adjustment, a dash-pot being fitted to prevent see-sawing, and is also fitted with an automatic safety stop.

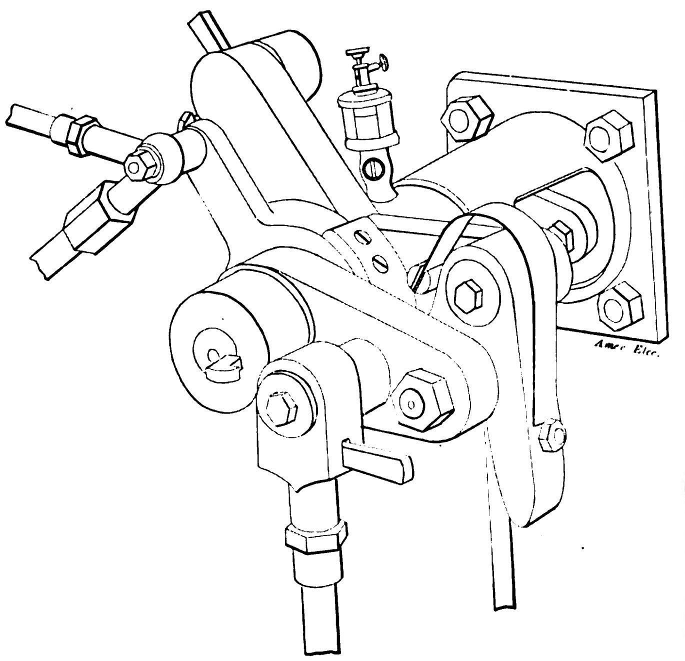


FIG. 37.—MURRAY RELEASING GEAR.

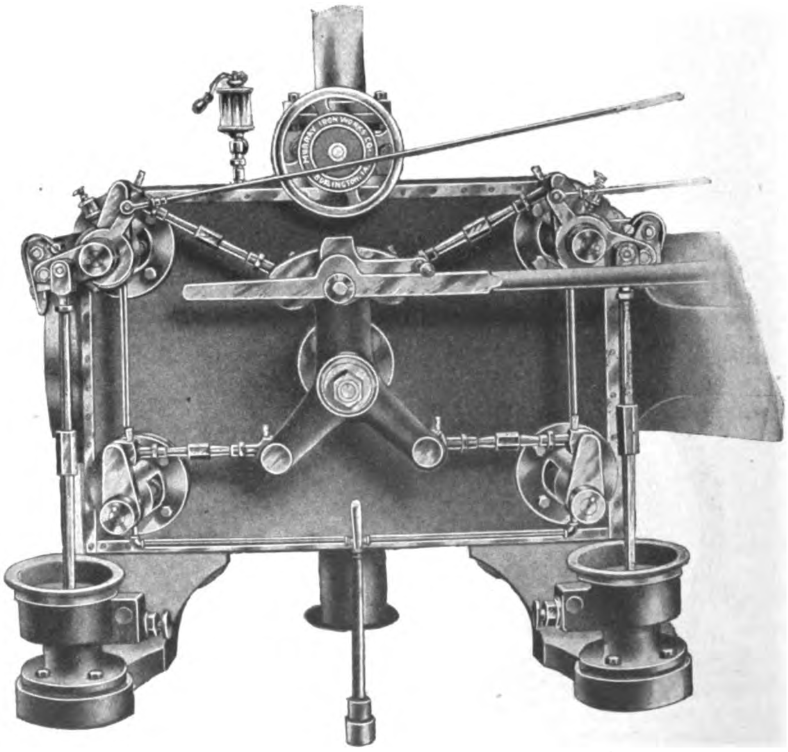


FIG. 40.—VALVE GEAR OF MURRAY ENGINE.

Figs. 42 and 42A illustrate the heavy box design of cross-head used on the Murray engine. It is fitted with adjustable habbitt-lined brasses turned to fit the bored guides. The piston rod is screwed into the head and secured by a lock nut and set screw.

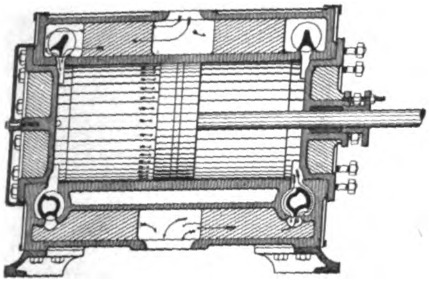


FIG. 41.—CYLINDER OF MURRAY SPECIAL ENGINE.

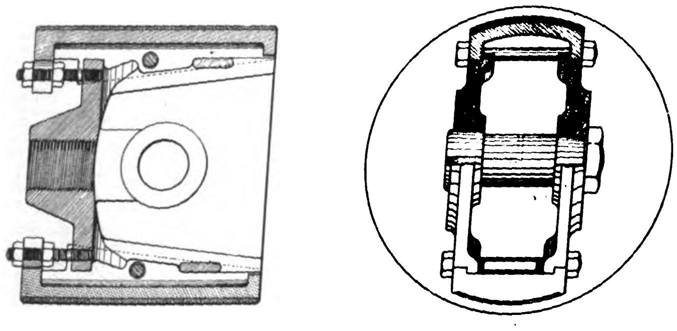


FIG. 42.—CROSS-HEAD MURRAY ENGINE.—42A.

The new style of connecting rod used is of the solid end variety.

Rice & Sargent Engine

An interesting example of Corliss engine design is shown in Fig. 43, illustrating a Rice & Sargent tandem compound built by the Providence Engineering Works, Providence, R. I. The frames of all the horizontal engines of this company are of the heavy duty type, made extra massive. The vertical engine frames are of the double "A" pattern. In the design of the cylinders of the horizontal engines, special care has been exercised to prevent undesirable results from expansion and contraction in the cylinder due to variations in temperature. Though it is absolutely necessary that the cylinders be held firmly to the foundation, provision must be made to allow the cylinder to move freely parallel to its axis, and this is accomplished in these engines by bolting one end of the cylinder to the foundation and fitting the other end with feet sliding in planed guides; in the tandem construction, the crank end of the high-pressure cylinder is bolted to the foundation and the other end, together with the entire low-pressure cylinder, is free to move in the guides which are securely bolted to the foundation. This construction can be seen by examining Fig. 43.

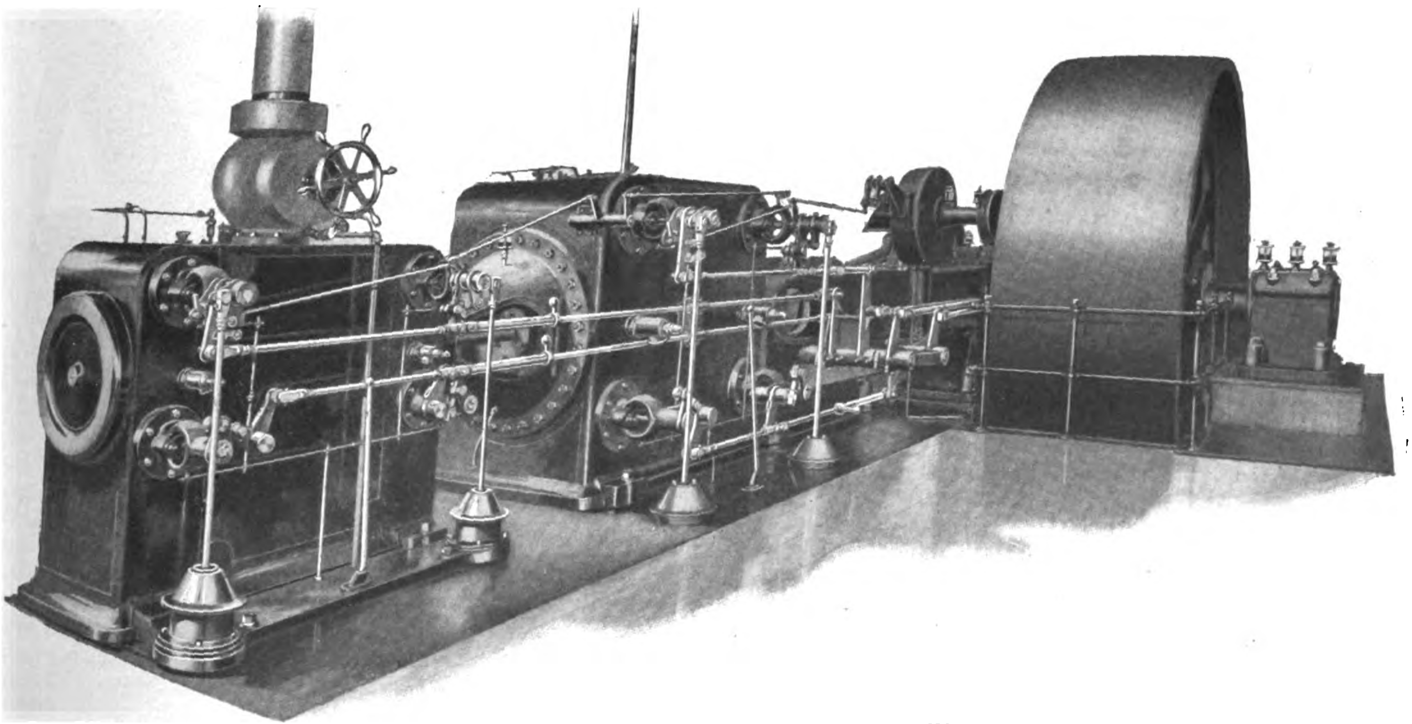


FIG. 43.—RICE & SARGENT TANDEM-COMPOUND CORLISS ENGINE.

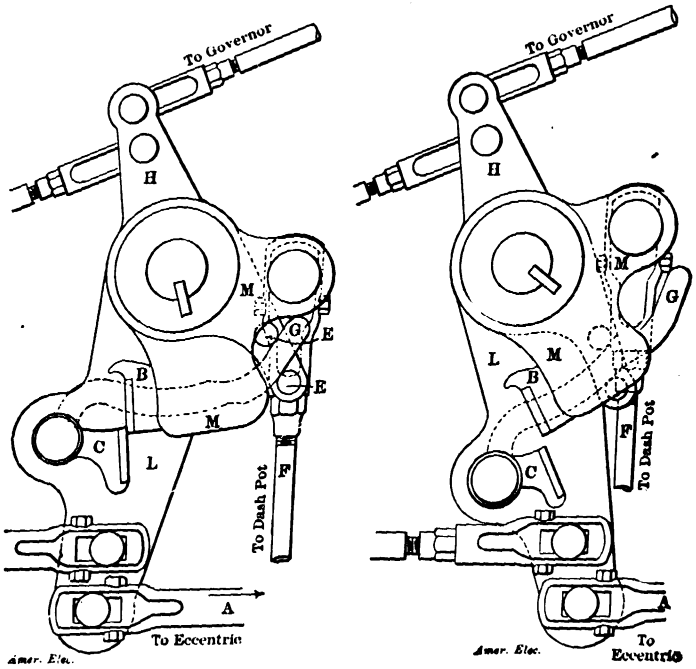


FIG. 44.—RICE & SARGENT RELEASING GEAR.—45.

Where jacketing is used, only the heads are jacketed unless otherwise ordered, for it has been shown that the head jackets are the most effective and that the barrel jackets are of doubtful value. The exhaust ports are cast away from the cylinder, and the steam ports in the usual manner. Double-ported valves are used on both the high and low-pressure cylinders, driven by the usual T-heads, and having the convenient feature of being removable from the rear, thus allowing them to be taken out for examination without disturbing the setting, or dismantling the gear. As they are double-ported the travel required is small. Probably the most striking feature of the design noticeable in Fig. 43 is the valve gear, which has three eccentrics and is devoid of the customary wrist plate. It is probably known to most readers that even in the direct expansion compound—that is, the tandem arrangement—it is desirable to open as well as to close the exhaust valves at different times in the two cylinders, the clearances and diameters of the cylinders being different. It is for this reason that three eccentrics are employed here, one to operate all four steam valves, one to work the high-pressure exhaust valves, and one to work the low-pressure exhaust valves. The steam valves are worked directly by the eccentric motion, and as will be noticed in the illustration, bell cranks and a short link exactly duplicate the wrist plate motion for the movement of the exhaust valves. This arrangement permits higher speeds of rotation without imposing racking strains on the valve gear.

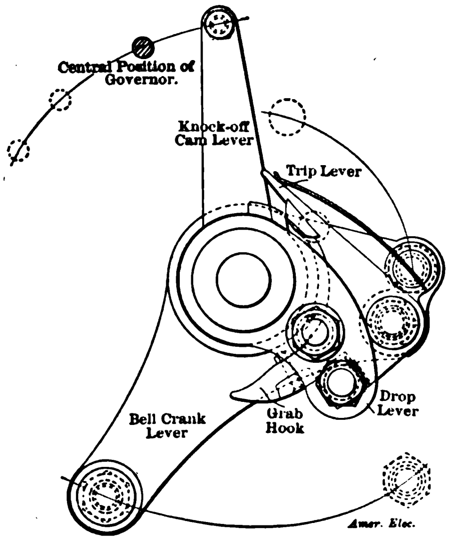


FIG. 46.—VILTER RELEASING GEAR.

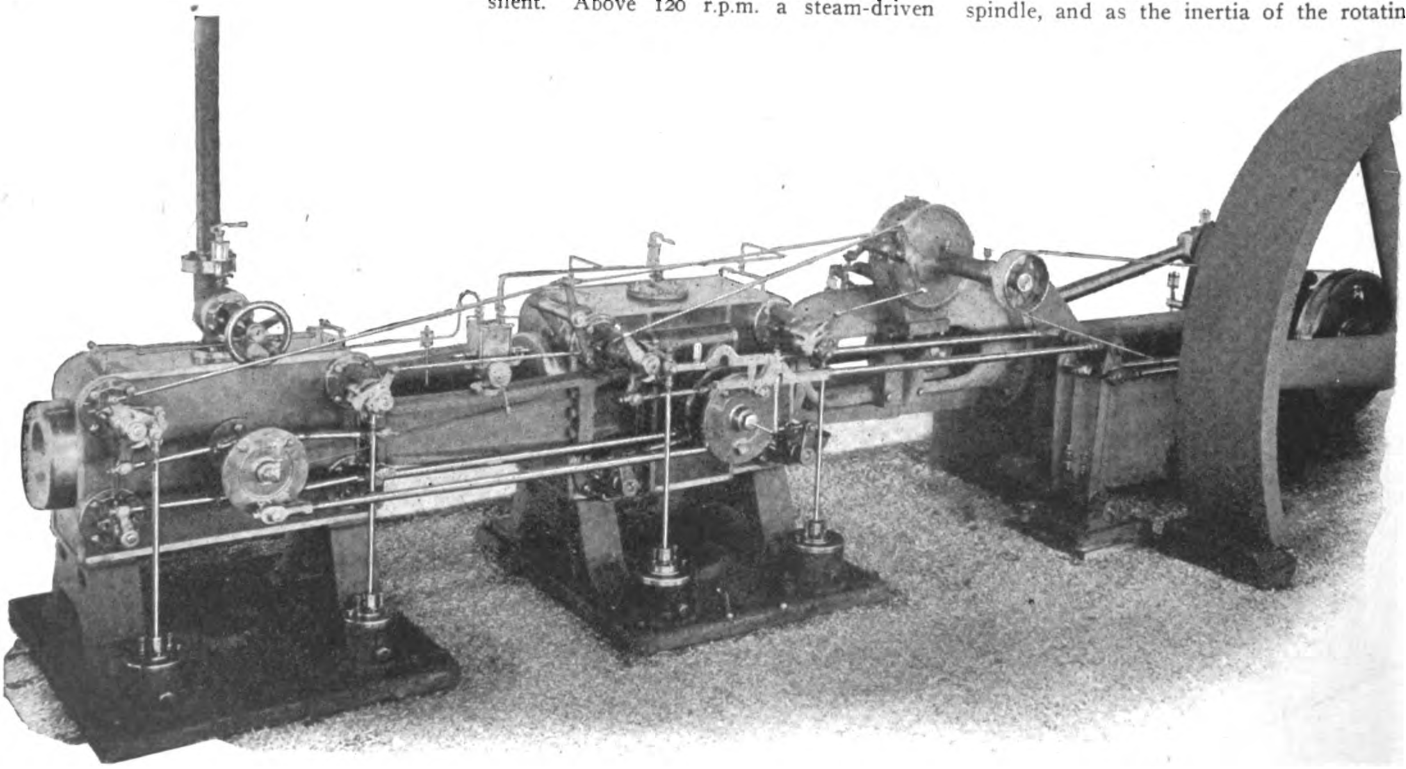


FIG. 47.—VILTER TANDEM-COMPOUND HEAVY-DUTY CORLISS ENGINE.

The releasing gear, shown by Fig. 44, is unique. It is without springs and can be worked at speeds up to 175 r.p.m. The lever, *L*, operated from the eccentric rod, *A*, carries the block, *C*, keyed to the end of a short shaft, to the other end of which is keyed the trip lever, *G*, which slides between the rollers, *EE*, mounted on pins carried by the lever, *H*, which is connected to the governor by a reach rod, *D*, and takes the place of the knock-off cam. In operation, the eccentric rod, *A*, moves in the direction indicated, the block, *C*, engages the catch block, *B*, mounted on the lever, *M*, which is keyed to the valve stem. When the point of release is reached, the trip lever, *G*, owing to its peculiar form, is thrown outward, releasing the catch block, *B*, and allowing the lever, *M*, to be drawn by the action of the dash-pot. The latch blocks have eight wearing edges which may be used in turn as they become worn. Dash-pots of the internal air chamber type are used for the closure of the valves; as no air escapes into the engine room, they are silent. Above 120 r.p.m. a steam-driven type of dash-pot is used to give the necessary rapidity for such high speeds.

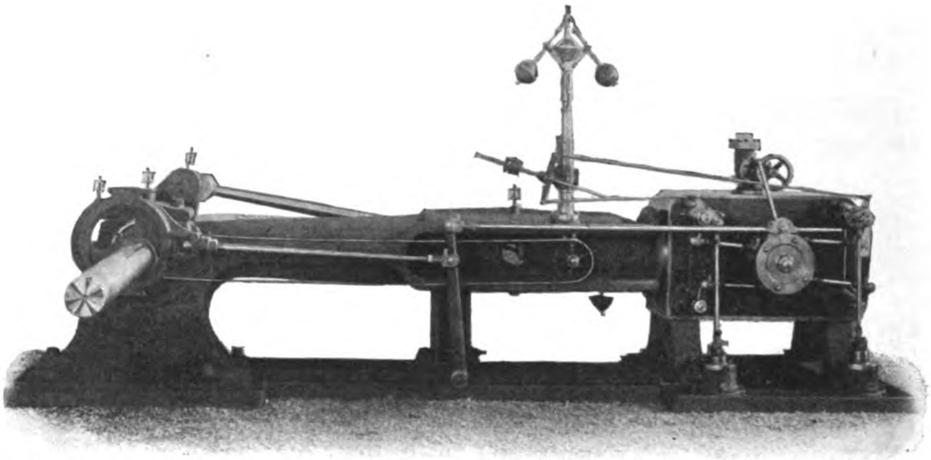


FIG. 48.—VILTER GIRDER-FRAME ENGINE.

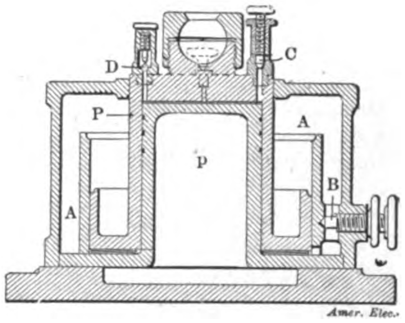


FIG. 49.—VILTER DASH-POT.

A modified Rites inertia governor displaces the customary fly ball governor. It is contained in a steel rim driven through link connections from the governor spindle, which is belted to the shaft. Within this rim are two weights which act by centrifugal force and hold the governor in its normal position, but any tendency which the engine shaft has to increase or decrease its speed is communicated to the governor spindle, and as the inertia of the rotating rim makes it tend to move at a constant velocity, a change in the position of the links takes place, which is communicated to the knock-off cam through the reach rod and thus changes the cut-off.

The Vilter Manufacturing Company, Milwaukee, Wis., are the makers of a complete line of simple and compound Corliss engines, of both the tandem and cross-compound variety. A rear view of one of their girder design of simple engine is presented in Fig. 48, which deserves attention in that the section through the guides differs from that of most makers, being an "I" section with the web vertical instead of horizontal; as is well known, the strength of an "I" section of normal proportions is greatest when the web is vertical. Up to 36-in. stroke, the frame is cast in one piece with the main bearing; in the larger sizes, however, the frames and pillow block are made of separate castings. Fig. 47 shows the Vilter heavy-duty frame, which is of a very massive and pleasing design, capable of standing the most severe service.

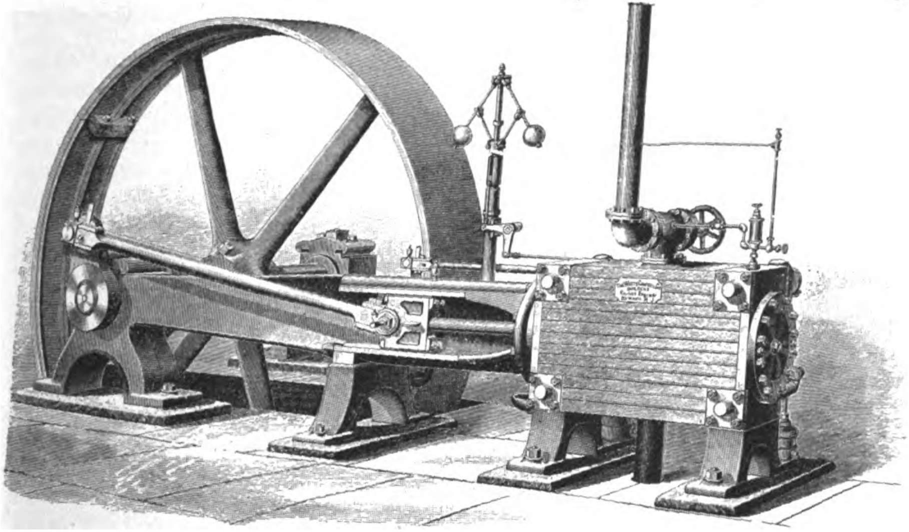


FIG. 50.—WATTS-CAMPBELL SIMPLE GIRDER FRAME ENGINE.

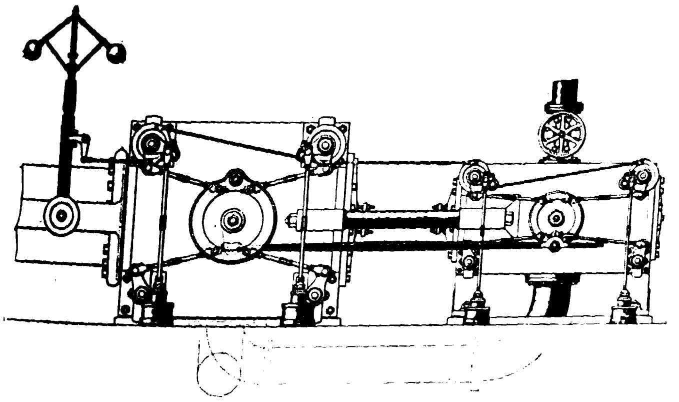


FIG. 51.—WATTS-CAMPBELL VALVE GEAR.

Valve gear of the usual under-type bell-crank construction is employed, with a wrist plate, which can be easily disconnected and moved by hand in starting should this be necessary. The releasing mechanism of this engine, shown in Fig. 46, differs from those previously described, as the grab-hook swings outward to engage with the latch blocks, making the wearing edges of the latch block easier of access for cleaning and lubrication while running; also with this arrangement it is possible to engage the grab-hooks without the use of springs, though light springs are provided so that when the wearing edges have become worn the springs insure the hook taking perfect hold.

Rapid closing of the valves is accomplished by the Vilter dash-pot shown in Fig. 49, the operation of which is as follows: As the plunger, *P*, which is hollow, and snugly fits the outside of the hollow stationary piston, *p*, is raised air is drawn in through the valve, *B*, from the chamber, *B*, and a partial vacuum is formed in the hollow piston, *P*, causing the pressure of the atmosphere to rapidly close the valve the instant release takes place, the air compressed in the circular chamber bringing the valve quietly to rest. Any air that has entered within the piston, *P*, escapes through the valve, *D*, as the piston settles home, the exit by way of valve *C* being too slow. The valve, *B*, regulates the amount of cushioning.

A variety of governors are used, the ordinary fly-ball, special fly-ball and an inertia type of governor; details of the latter two are not available at the present writing. Box type cross-heads with babbitt-lined shoes, adjustable for wear by wedge take-ups, are used, the shoes working in bored guides, which prevents the heating of the crank pin in case the outboard foundation should settle. The connecting rod is made of hammered iron with solid ends fitted with screw and wedge adjustment and babbitt-lined brasses. A hammered-iron crank shaft is used, on which the crank is forced by hydraulic pressure, after which it is securely keyed.

Watts-Campbell Engines.

A variety of styles of simple, tandem and cross-compound horizontal girder frame engines are manufactured by the Watts-Campbell Company, Newark, N. J., of which Fig. 50 presents one of the former class, and illustrates the construction of the governor, cross-head, connecting-rod and fly-wheel. The frame, which is cast in one piece with the main bearing pillow-block, is of the "bayonet" form rather than the usual "I" section, well supported under the ends of the guides. The piston is of very much the same type as that of the preceding engine, it also being secured to the piston rod by a cross key. V-shaped guides are used, and a cross-head of the box type having a lateral wedge adjustment of the slippers and cross key attachment to the piston rod.

Fig. 51 illustrates the valve gear which is of the under bell-crank construction; all the rods are adjustable for length and have quarter boxes adjustable by screws to take up the wear. The use of steel rod distance pieces between tandem cylinders is also shown in this engraving. These permit removing the low and high pressure cylinder covers without dismantling the engine, and also give freer access to the intermediate stuffing boxes. Simplicity and efficiency are combined in the relasing gear used, shown in the engravings. Its construction and operation will be understood by examining Fig. 52, in which *A* is the bell-crank lever, carrying the shaft, *E*, one end of which is semi-circular, while to the other end is keyed the trip lever having the roller, *D*, at its other end; this roller is held in contact with the knock-off cam, *C*, by the flat spring, *S*. When the wrist-plate rod, *W*, moves in the direction of the arrow, the semi-circular end of the pin, *E*, engages the steel die on the drop lever, *B*, raising it and opening the valve. The dash-pot is of the hollow plunger type described in connection with some other engines. The minor differences may be

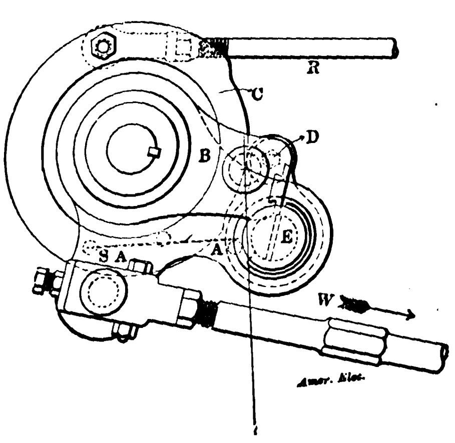


FIG. 52.—RELEASING GEAR.

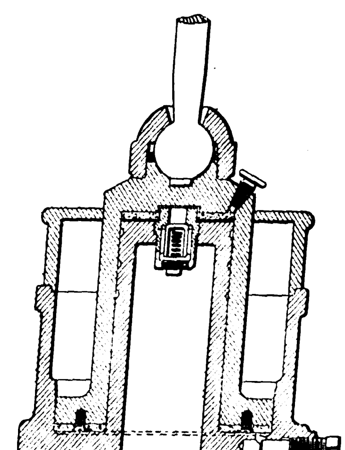


FIG. 53.—WATTS-CAMPBELL DASH-POT.

readily noted by reference to the cross-section Fig. 53. In condensing engines, air pumps situated under the engine-room floor are driven directly from the cranks by rods working levers passing through the floor, and to which the pump plungers are connected.

Wetherill Corliss Engines.

The rear view of the simple engine illustrated by Fig. 55 shows the type of girder frame and arrangement of the valve-gear used by Robert Wetherill & Co., Philadelphia, Pa. These engines are made in a variety of forms, including heavy duty tandem and cross-compound multiple expansion engines especially designed to meet the requirements of electric lighting and railway service. A small but important improvement in the design of the girder frames is the heavy rib extending up around the top of the guides from the center support, and also the feature of having the foundation bolt extend through the web of this rib, thus strengthening the construction and making it just as rigid for an engine running "under" as one running "over." Two styles of cross-head are used, the ordinary style of box cross-head with screw and nut connection to the piston rod being used on the smaller sizes. On the larger sizes of engines the construction shown in Fig. 54 is employed. The illustrations are self-explanatory, but it may be added that this is a very satisfactory construction and is capable of fine adjustment with little trouble.

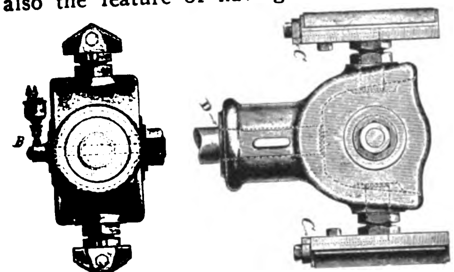


FIG. 54.—WETHERILL CROSS-HEAD.

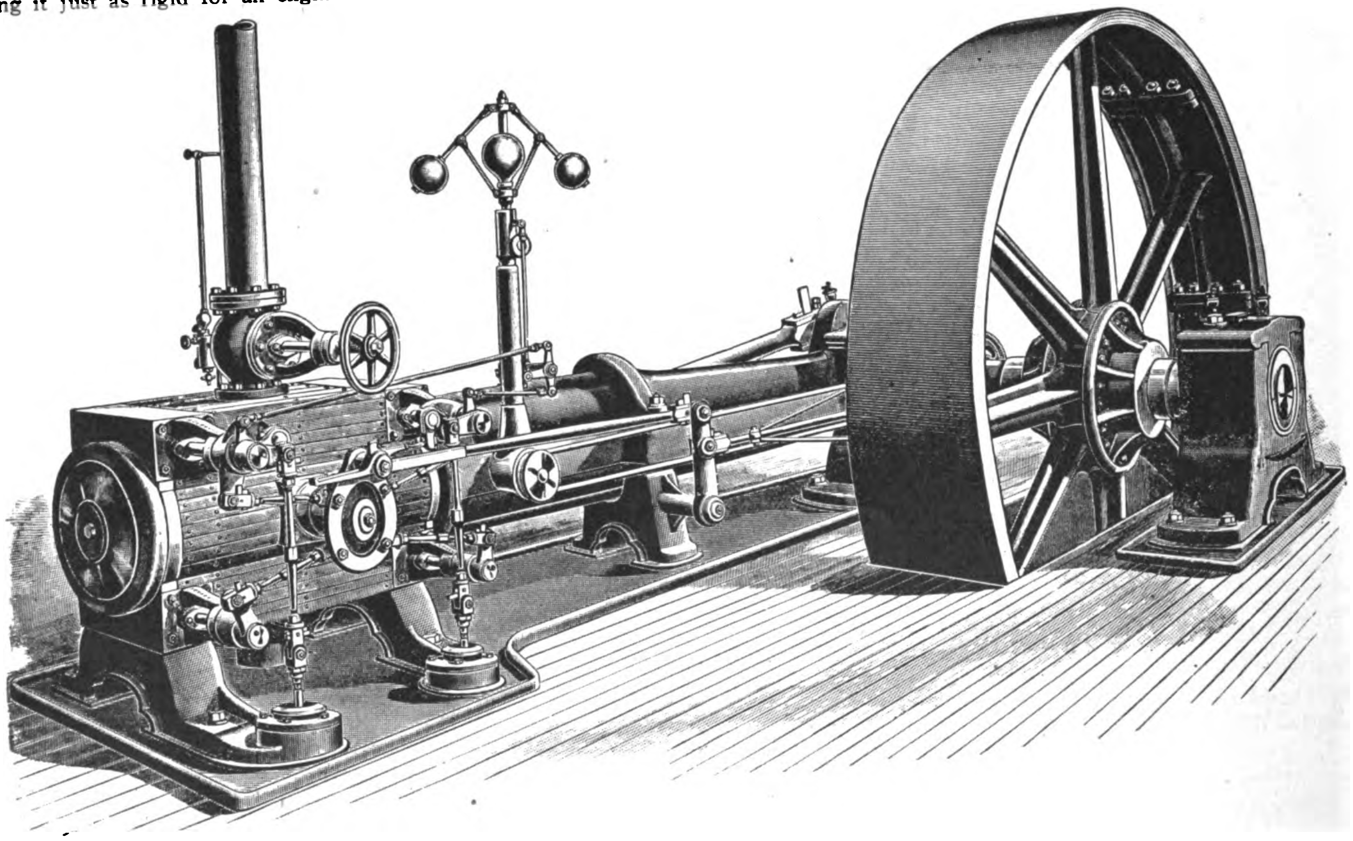


FIG. 55.—WETHERILL SIMPLE GIRDER-FRAME CORLISS ENGINE.

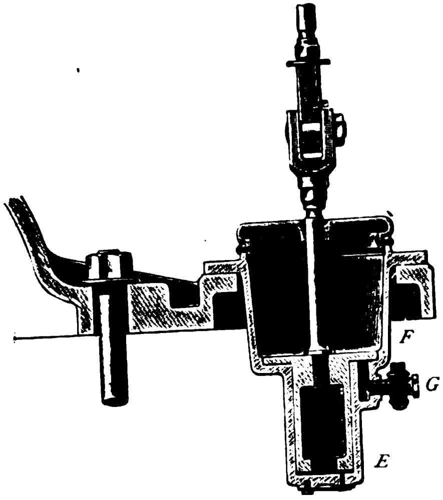


FIG. 56.—WETHERILL DASH-POT.

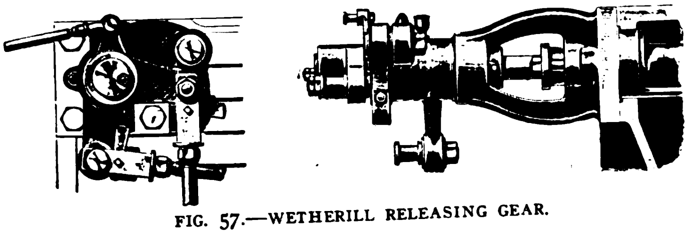


FIG. 57.—WETHERILL RELEASING GEAR.

The piston is cast in one piece, hollow, stiffened with internal ribs, and is made steam tight by patented piston rings pressing against the cylinder wall by elliptical springs, which are made of German silver because that material is not changed by exposure to high temperatures. A well designed form of standard Corliss releasing gear is employed on these engines illustrated in Fig. 57, and the dash-pot used in conjunction with it is shown by Fig. 58. The operation of the dash-pot will be understood by reference to the illustration.

Westinghouse Steam Engines.

The line of reciprocating steam engines manufactured by The Westinghouse Machine Company, Pittsburg, Pa., embraces a number of distinct types both single and double acting.

The Corliss types of engines are essentially heavy-duty, compound, condensing engines. Until recently all of the Westinghouse engines were of the vertical pattern. A horizontal Westinghouse-Corliss engine of both tandem and cross-compound types has, however, just been brought out, and occupies an intermediate position between the marine and the larger Corliss types. Unfortunately, this engine is not yet ready for description, but it will be described in a future issue.

The vertical cross compound, and the vertical three-cylinder compound engines have many similar features. Both are fitted with either Corliss or poppet valve gear, the latter usually being applied only to the high-pressure cylinder when highly superheated steam is employed. The dominant features of the two types are identical even to the extent of interchangeable parts. The construction consists mainly of a single or sectional bed plate, supporting the bearings and surmounted by split housings or A-frames enclosing the crank pits. These in turn support vertical cross-head guides, which are surmounted by the engine cylinders. Both types are fitted with receivers usually arranged for reheating between cylinders, and with galleries extending completely around the engine at three levels, *viz.*, the tops of the housings, cross heads, and cylinders respectively.

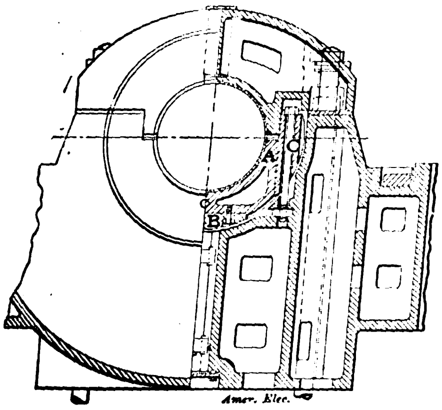


FIG. 58.—WESTINGHOUSE MAIN BEARING.

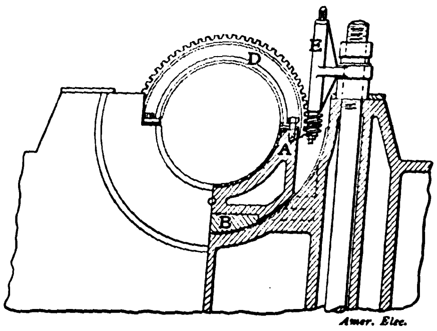


FIG. 58-A.

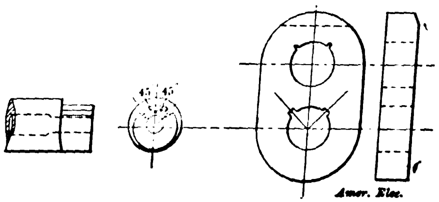


FIG. 60.—WESTINGHOUSE DETAIL.

In the three-cylinder type the rotating element of the generator is mounted upon an extension to the engine shaft with an outboard bearing. The bed plate is, however, continuous, although made in six sections; three for the generator and three for the engine. The various sections are tongued, grooved and united by shrunk arrow-head links. In the New York Edison engines the necessity of reducing the elevation of the shaft resulted in the depression of the generator footing 3½ feet below the engine footing, or 4½ feet below the floor level.

The designs of journals for the two types are radically different, owing to the flexibility necessary in the one case and not in the other. The main journals of the cross compound are of the ball and socket type, and water-cooled. The upper half of the journal combine the function of a cap and bearing shell, and one-half only is utilized for securing the requisite upper bearing surface, this half only being babbited. By removing this cap and easing the shaft off its bearings the lower shell may be slid out of its socket for inspection or renewal, this avoiding the necessity of dismantling the engine to any extent. The main journals for the three-cylinder engine are of the same removable type, but have cylindrical instead of spherical seats, machined with a boring bar after the assembling of the bedplate sections. The lower bearing shell is further provided with side and bottom packing pieces, *B* and *C*, Fig. 58. When it becomes necessary to compensate for wear, shims may be inserted between the shell and packing-piece, *B*. The rigging shown in Fig. 17 is provided for removing the lower shell; the segmental rack, *D*, and the worm shaft, *E*, are assembled after removing the bearing cap. After easing the shaft off of its bearings the worm is operated by a ratchet wrench, and the lower shell, *A*, is thereby rotated through an angle of 180° to a position on top of the shaft, where it may be easily removed, or adjusted.

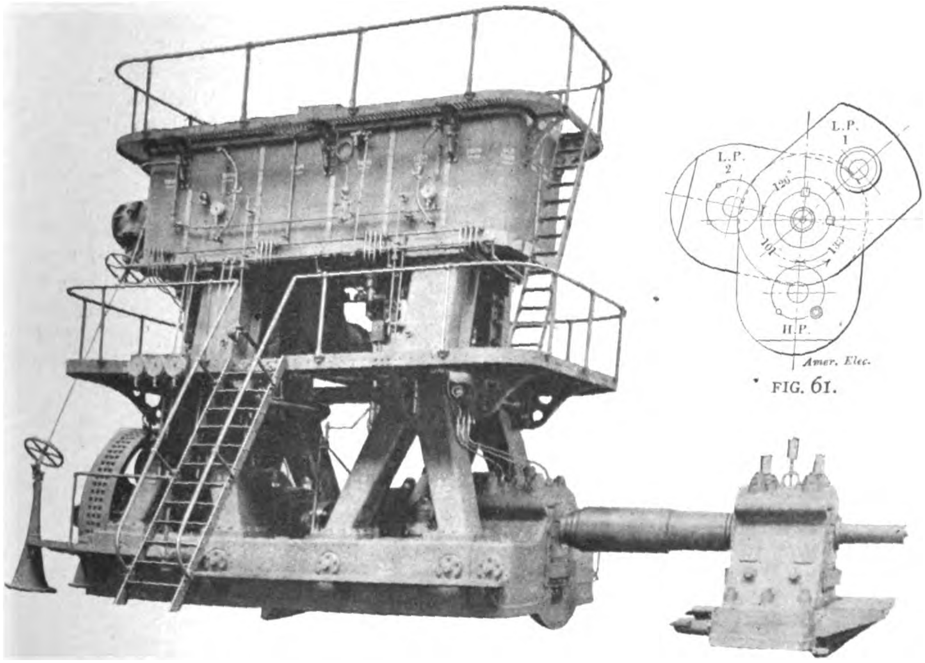


FIG. 59.—WESTINGHOUSE MARINE TYPE ENGINE.

FIG. 61.

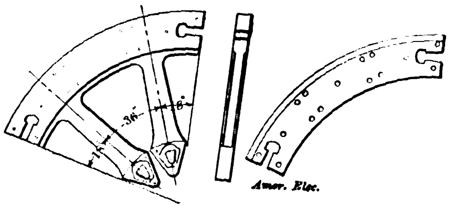


FIG. 62.—FLY-WHEEL DETAIL.

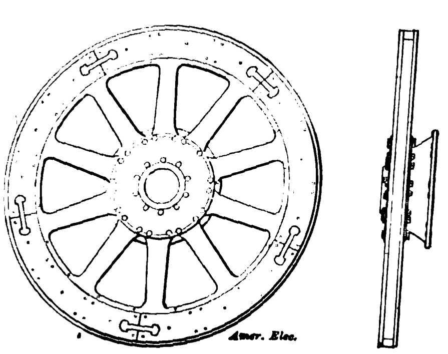


FIG. 63.—WESTINGHOUSE FLY-WHEEL.

merely a mimimum amount of machining at

The steel shafts for all large engines are forged at the steel works in such form that the shops is necessary to produce a finished article. Fig. 61 shows the arrangement of the cranks of the New York Edison engines, which are three-cylinder compounds. The cranks are placed at angles of 101°, 126° and 136° from each other, instead of 120°. This spacing was chosen for its peculiar effect upon the uniformity of angular rotation. In an engine with cranks spaced at 120° the angular displacement with a given fly-wheel effect was found to be much greater at the most economical load than at the point of maximum load. It is evident that in electrical power work with slow-speed, direct-connected generators, the opposite effect would be more desirable, *viz.*, to obtain a mimimum angular displacement at the most economical loads rather than maximum loads, which are seldom more than momentary. The arrangement of the cranks at the irregular angles noted has to a large degree secured this result. Another point of interest in the crank and shaft construction is shown by Fig. 60. The end of each shaft section where it is turned down to fit the crank is turned eccentric to the bore, to the extent of 1½ inches, in order to provide this amount of extra metal in the disc between shaft and pin. The three sections of this shaft are assembled in the shop with straight press fits. The crank pins are, however, mounted on the ground, in order to allow the shaft to be shipped in sections.

The fly-wheels for all large work are built-up, as indicated in Figs. 62 and 63. The rim center is cast in segments, each embracing 72° of the circumference, and having two arms attached. These are bolted to the fly-wheel hub, and the segments of the arm secured by arrow-head shrunk links. Additional segments are then mounted upon each side of the rim center, each of which likewise embraces 72° of the periphery, and after being assembled upon the rim center with joints overlapping, these outer rims are united by shrunk links independently of the central rim. The three sections of the rim are then bonded by steel pins compressed and riveted over by a hydraulic press.

The housings for the two-cylinder and three-cylinder compounds are practically identical. They are split along a vertical plane, and the two halves are united in the interior by turned bolts with ream fit. The three-cylinder housings are forked at the rear to provide better access to the cranks. Cross-head guides are grooved and doweled to the housings and cylinders, and have water-jacketed guides bored concentric with the top and bottom flanges. They also have side openings to permit the removal of the cross head, if necessary.

Several important features are embodied in the cross head, the design being shown in Fig. 66. The shoes are provided with a flange at each end, which fits over the end of the cross head and are positively-driven thereby, thus relieving the adjusting screws of all reciprocating stress. The shoes are adjusted by means of internal wedges. Both the inner and the outer surfaces of the shoe are turned concentric with the bore of the guides, so that by the removal of the adjusting screws the shoes may be readily slid out of position without dismantling the engine or disturbing the adjustment of the remaining parts. A simple device for retaining and measuring the adjustment of the jam nut upon the piston rod consists of a metal arc tap-bolted to the top of the cross head and fitting the hexagonal sides of the nut. Circular slots are provided so that the arc and nut may be rotated when the tap bolts are slackened off. The rod itself is prevented from turning by a pin screwed through the neck of the cross head and entering a corresponding hole in the threaded portion of the piston rod.

The connecting rod of the cross compound is solid-ended, with split wedge adjustment of the boxes; on the three-cylinder compound a solid-ended rod with a babbitted bronze box at the cross-head and the marine open-end type at the crank pin is used. The connecting rods of this engine are bored throughout their length with a 4-in. hole for securing good metal, and incidentally for conducting oil to the crank pins. The duct is fed by touch cups at the cross-head.

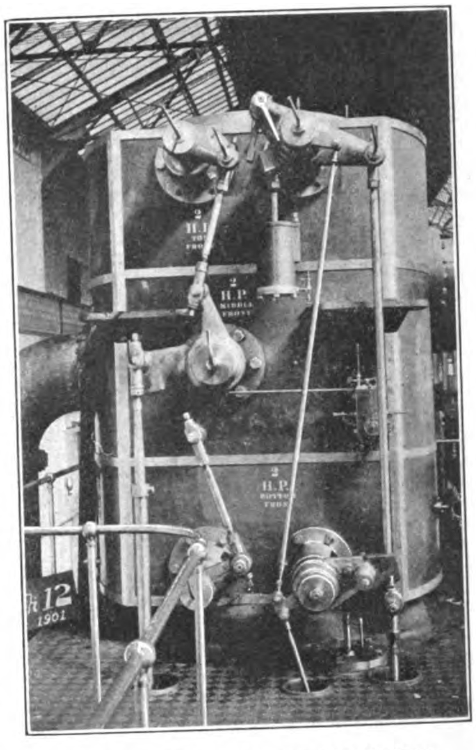


FIG. 65.—HIGH-PRESSURE VALVE-GEAR.

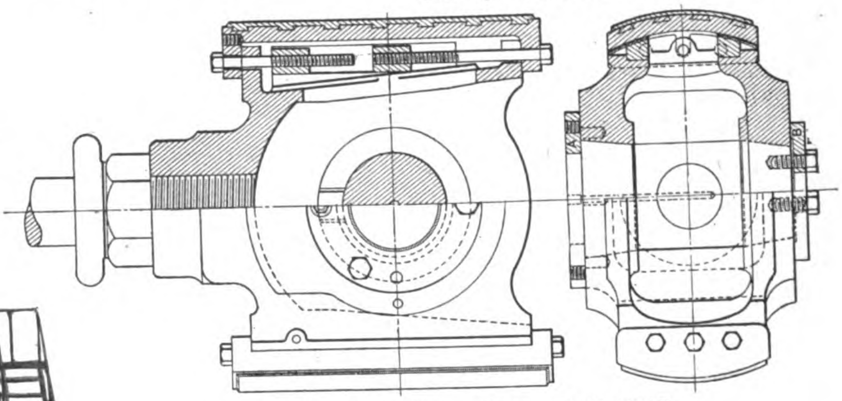


FIG. 66.—WESTINGHOUSE CROSS-HEAD.

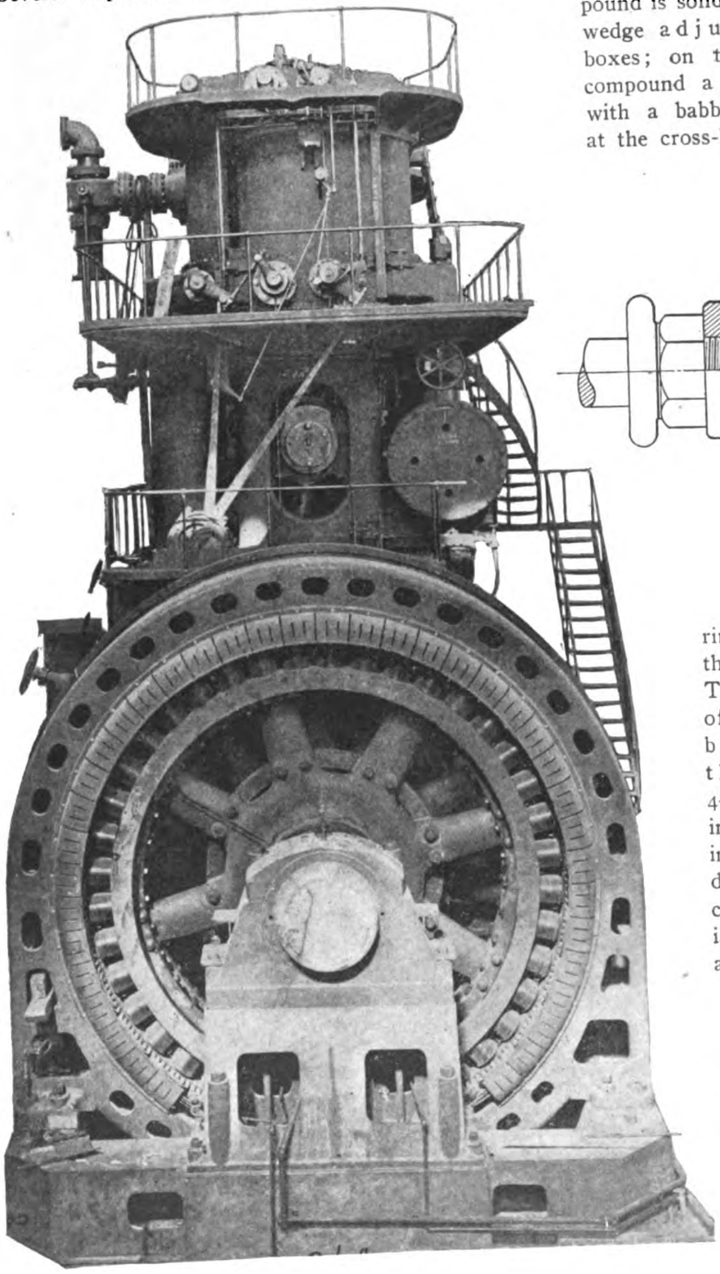


FIG. 64.—WESTINGHOUSE THREE-CYLINDER COMPOUND.

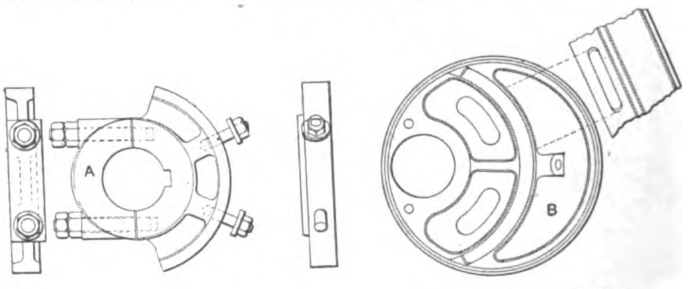


FIG. 67.—WESTINGHOUSE ECCENTRIC CONSTRUCTION.

Two types of valve-gear are used, as determined by the character of the steam supply and other considerations. For engines operating under high pressure without superheat the Corliss type of gear is used on both cylinders, but in the case of the New York Edison engines, where a considerable degree of superheat is employed, the poppet valve-gear has been applied to the high-pressure cylinder. Figs. 64 and 65 show a typical Westinghouse-Corliss gear. The admission valves at the right are arranged for either manual or automatic governing of cut-off, ranging from 0 to ¾-stroke, while the exhaust valves at the left are actuated by a fixed eccentric, as usual. The arrangement of the gear parts are such that the toggle motion gives quick opening and closing, with a pause during the periods of admission, expansion and exhaust. The engagement levers are not made in a single piece, as is quite common in Corliss valve gear, but the hook and knock-off are assembled at the opposite ends of a short spindle and held in position by a flat steel spring.

The valve gear of the two-cylinder engine is operated by rock-shafts oscillated by eccentrics mounted on the main shaft, and in the case of the three-cylinder engine from a secondary eccentric shaft, mounted on the first platform of the engine, as shown in Fig. 65. This secondary shaft is driven from the main shaft through a spiral gear transmission.

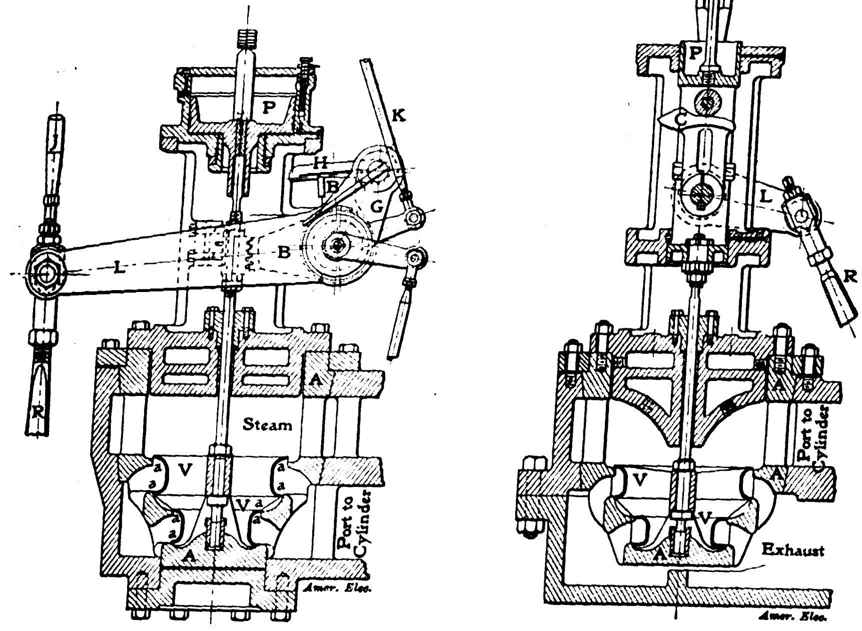


FIG. 68.—WESTINGHOUSE ADMISSION AND EXHAUST VALVES.—FIG. 69.

Fig. 67 shows the eccentric construction. The body of the eccentric, *B*, is mounted on a split sleeve, *A*, which is provided with a peripheral flange to which the eccentric is bolted. This permits a considerable angular adjustment without disturbing the position of the sleeve, *A*, which is keyed to the eccentric shaft. Each set of valves upon each cylinder is operated, of course, from an individual eccentric.

Speed regulation in both types of engine is accomplished by a centrifugal ball governor belted to the main shaft in the two-cylinder type and geared to the secondary shaft in the three-cylinder engine. The cut-offs in both cases are controlled from a secondary governor shaft mounted beneath the second platform.

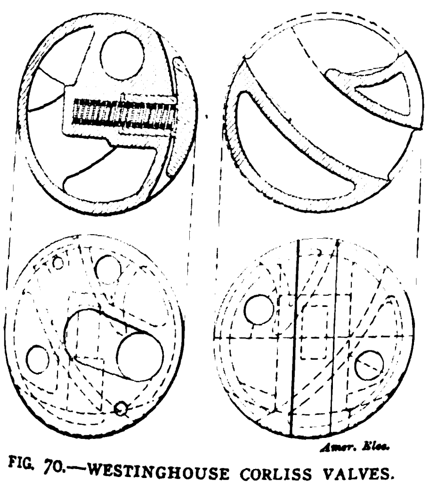


FIG. 70.—WESTINGHOUSE CORLISS VALVES.

A simple device is used for controlling the speed of the engine within a small range during the synchronizing of the generators. Upon the bed plate of the engine, between two of the housings, is mounted a small iron-clad motor which, through a suitable gearing, is arranged to move a weight back and forth along a horizontal arm. This arm, at its outer end, engages a vertical rod connecting with a lever upon the secondary governor shaft, and serves to "buck" the centrifugal governor. When the engine is running at a definite speed the slightest movement of this weight results in an increase of resistance to the governor and a corresponding change in speed. The motor may be disconnected and the apparatus operated by hand from the ground level, but it is intended to be controlled from the switchboard by a throw-over switch, by means of which the rotation of the motor may be reversed.

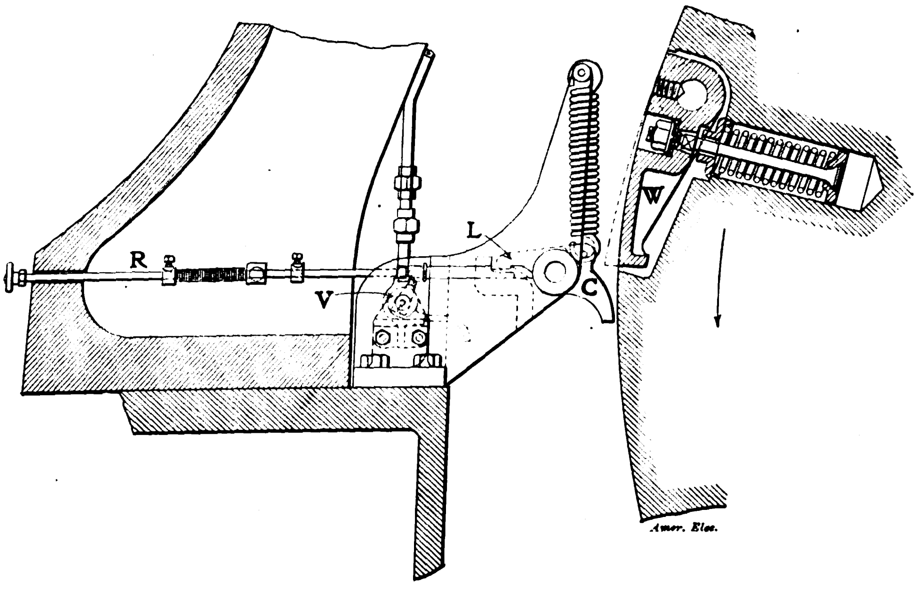


FIG. 71.—WESTINGHOUSE SAFETY STOP CONTROLLING MECHANISM.

The mechanism of the poppet valve-gear on the high-pressure cylinder is shown in Figs. 68 and 69, which show sections of the admission and exhaust valves respectively. The valves are of the four-beat poppet type, mounted vertically in extensions to the high-pressure cylinder casting at the bottom end and in the cylinder head at the top. The lift is transmitted from the eccentric rod, *R*, through the lever, *L*, to the hook, *H*, the latter engaging the bell crank lever, *B*, which raises the valve steam until the hook is released by the governor gear. The valve then descends, aided by the pressure of a leaf spring, but its motion is retarded just at the point of seating by the compression in the dash-pot, *P*, through which the valve is eased on to its seat. The rods *J* and *K* transmit similar motion to the valve gear upon the top of the cylinder. The lift of the exhaust valve is obtained by means of the cam, *C*, actuated by the lever, *L*, and eccentric rod, *R*, the angularity of which, together with the curvature of the cam, serves to secure quick opening and closing. Both valves, *V*, *V*, are mounted in independent cages, *A*, which are held in place by retaining rings, as shown. On the low-pressure cylinders, double-ported Corliss valves, as shown in section in Fig. 70.

The apparatus shown in Fig. 71 is a safety stop, and is operated by centrifugal force. The trip lever, *W*, is mounted in the periphery of the outer crank disc, and its tendency to fly outward is resisted by a spiral spring. When the speed exceeds the safe limit, this lever flies out, and through the lever *C* unlatches the valve rod, *R*, which operates a small triple-ported valve connected by small brass piping to the stop valve. This allows steam to enter the piston of a stop valve at the top of the high pressure steam supply pipe and causes its descent against the slightly overbalanced pressure of the high-pressure steam. This trip mechanism may also be operated from the exterior of the engine, by twisting the rod, *R*, a half turn in either direction. The throttle valve of the engine may be operated from either of the two lower platforms, or from the floor through a suitable gearing.

MEDIUM SPEED ENGINES.

Passing from the slow-speed releasing-gear to the medium-speed engines, Fig. 72 shows a form of engine differing in its valve-gear from that of those preceding chiefly in that it is non-releasing. This is one of the vertical medium speed engines of The Ball & Wood Company, of New York and Elizabethport, N. J. These engines are made in the horizontal tandem compound and cross compound forms, and in vertical cross-compound form. The cylinder barrel is a simple tube flanged at the ends; the valves are placed in the cylinder heads, thus obtaining short steam ports and small clearance. As shown by the engraving, the frame is of very massive construction. It is entirely closed while running, but free access to all the moving parts is given by large man and hand-holes. Pistons of the box type are used, held to the tapered end of the piston rod by a lock nut.

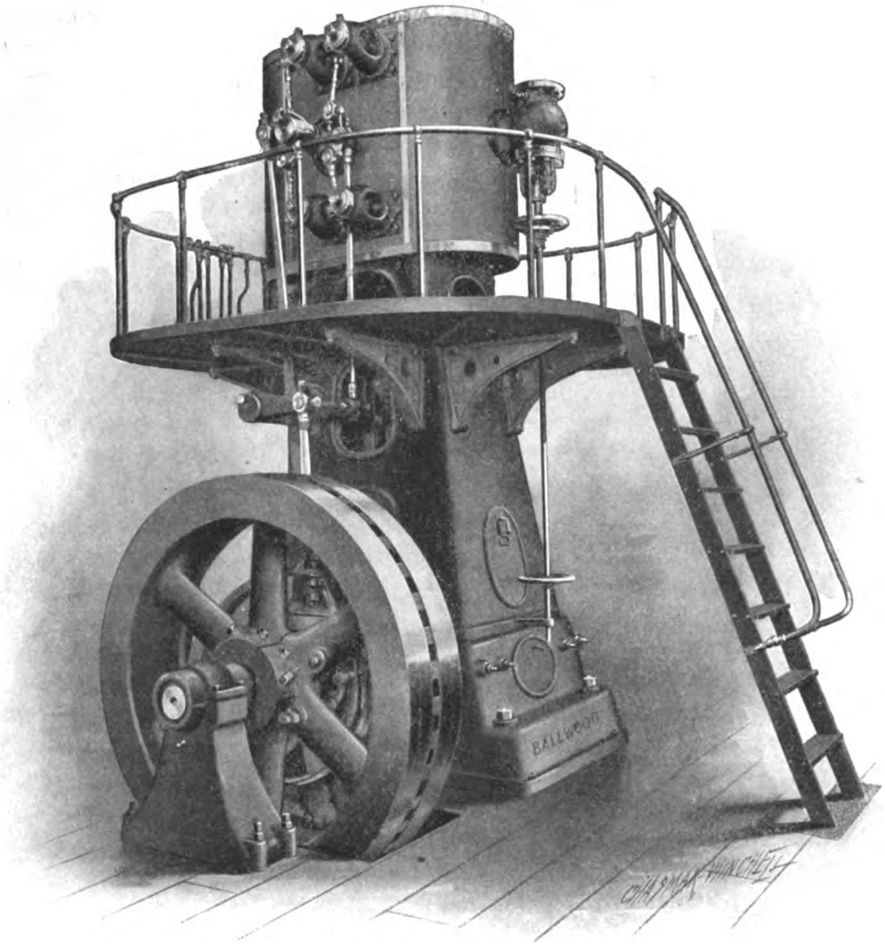


FIG. 72.—BALL & WOOD VERTICAL ENGINE.

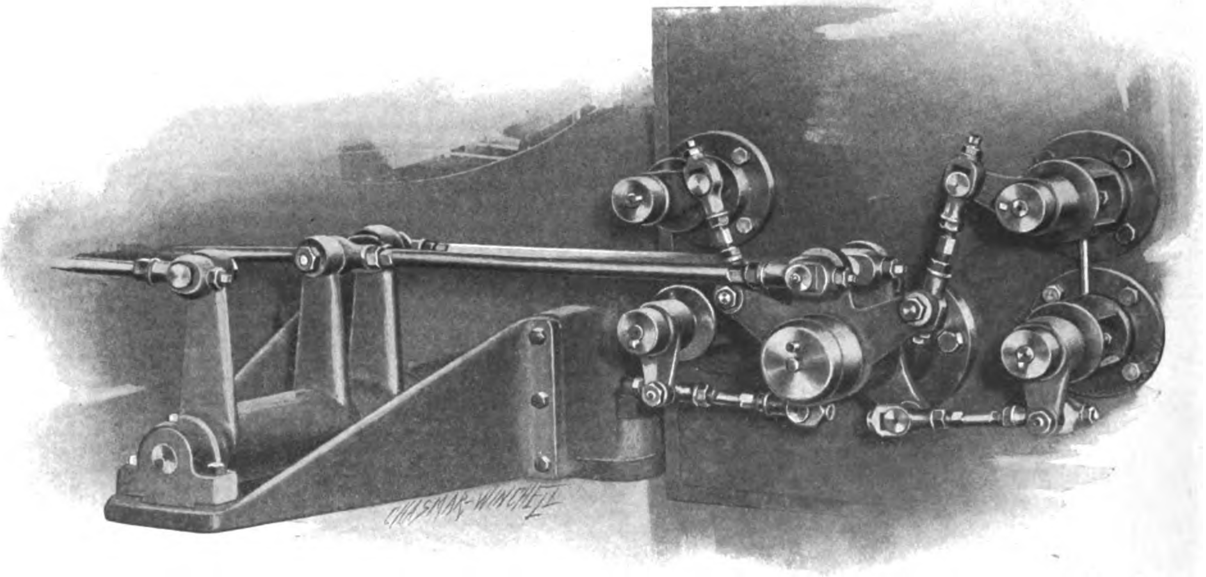


FIG. 73.—VALVE-GEAR OF BALL & WOOD HORIZONTAL FOUR-VALVE ENGINE.

Double-ported Corliss valves are operated by the valve-gear shown in Fig. 73, in which it will be noticed that the exhaust and steam valves are each operated from a wrist-plate of the skeleton form and worked by separate eccentrics. In tandem compound engines the practice of having separate eccentrics to operate the exhaust valves in the different cylinders is followed, for the reason previously explained. The eccentric which operates the steam valves is under the control of an inertia shaft governor of the form shown in Fig. 110, excepting that there are two centrifugal weights and two springs instead of one.

When the wheel is turned the weights force the arms outward against the action of the springs, pulling on the small links connecting them to the inertia bar carrying the eccentric pin on a small projection, and thus moving the eccentric in towards the center of the shaft and shortening the stroke, cutting off the steam earlier in the cylinders. The centrifugal force only defines the speed at which the engine shall run, and any tendency to increase or decrease in speed is corrected by the inertia bar. As the eccentric pin swings across the shaft, it varies the angular advance, and consequently the lead, giving a maximum when the load is a maximum and zero lead when running with no load.

In the vertical engines the cross-head used is of the box type, fitted with babbitt wearing surfaces and running in bored guides, while in the horizontal class the guides are of the locomotive pattern with fattened cross-head pins. The piston rod is made of hammered crucible steel, screwed into the cross-head and secured by a nut. The pillow blocks for the main bearings are fitted with interchangeable babbitt liners, scraped to fit their seats and the journal.

C. H. Brown Engine.

Some interesting features are incorporated in the design of the tandem compound engine shown in Fig. 75, made by C. H. Brown & Co., Fitchburg, Mass. The frame ordinarily employed is of the girder type, but on engines for electric lighting and railway service a tangye frame made in two parts bolted together is used, as is now quite generally the practice. A support under the center of the guides and an opening in the front of the main bearing pillow block which permits the engineer to feel the brasses themselves are among the external features. The outboard bearing pillow-block rests on a sole plate, by which it is made adjustable.

Gridiron valves are used for both the steam and the exhaust, the former being located at the side of the cylinder and the latter under it to facilitate freeing it of water. From the section through the cylinder shown in Fig. 77, it will be seen that the steam valves are fitted with a releasing gear of the Sickels type, slightly modified, while the exhaust valves are worked positively from a separate eccentric. The operation of the releasing gear, as well as its construction, will be readily understood by referring to the engraving, in which *B* is a bell crank carrying on its lower arm the catch block, *A*, which engages with the hook, *C*, mounted on a pin on the valve stem guide, *D*. As the block, *A*, is raised, the valve will be opened and will continue to remain open until the tail of the hook, *C*, engages with the trip lever, *E*, which detaches the hook, permitting the pressure on the unbalanced area of the valve stem to close the valve quickly, all shock being prevented by the dash pot, *F*. The trip lever, *E*, as in other detaching gears, is under the control of the governor. A very satisfactory motion is imparted to the exhaust valve by a link and rock lever, as is clearly shown in Fig. 76; the rod, *A*, has a reciprocating motion given to it by the exhaust eccentric and transmits it to the rocker, *C*, by the link, *B*. It will be evident from the diagram that the valve will open and close quickly, but will remain nearly at rest while in its extreme position. The arrangement of the valve gearing and rockers is fully illustrated in Fig. 75, in which it will also be observed that the low-pressure cylinder is supplied with oil by a small pump operated from the exhaust valve motion.

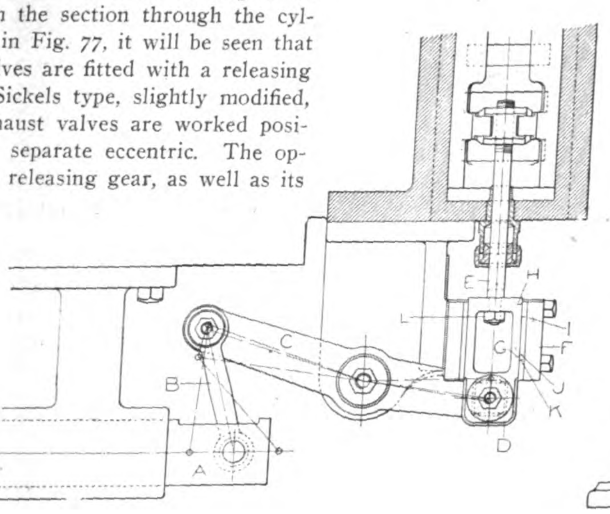


FIG. 76.—BROWN EXHAUST VALVE.

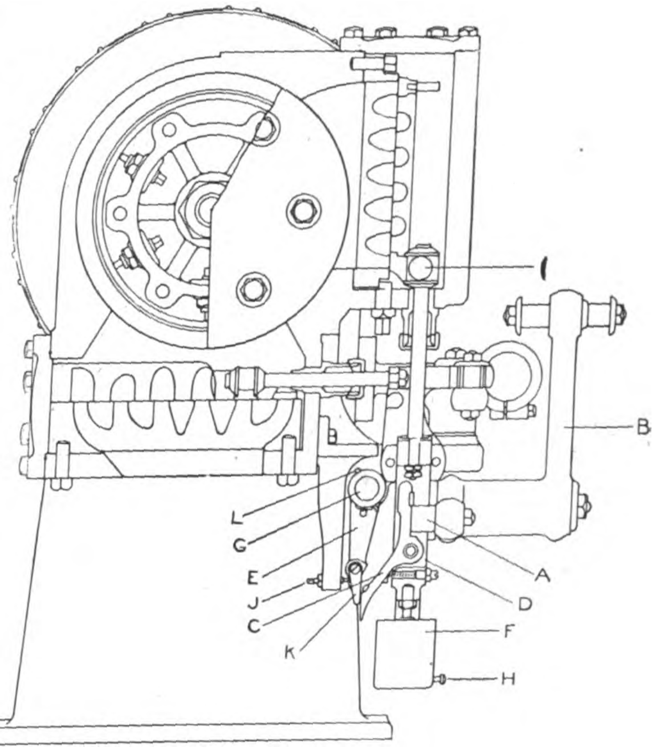


FIG. 77.—SECTION OF BROWN CYLINDER.

Fitchburg Engines.

Fig. 81 illustrates the medium speed four-valve engine of the Fitchburg Engine Company, Fitchburg, Mass., the engraving showing the tandem compound style. A tangye bed is used having the guides made and finished separately from the bed to which they are bolted. It will also appear upon examination of the illustration that the rocker arms are supported on a separate base bolted to the foundation, this differeing from the usual practice, which is to support the arms directly on the frame of the engine or on brackets bolted to it. All the valves are of the piston type, the exhaust valves being driven from fixed eccentrics. A wide departure has been made in the design of the admission valve mechanism, each valve being independently operated. Fig. 80 illustrates this valve-gear, which consists of two independent double-ported Trick piston valves having their rods attached to two cams, *D*, *D*, which are free to reciprocate in guides. Motion is imparted to these, through the bell-cranks, by the eccentric controlled by the governor.

Both the exhaust and the steam valves are made adjustable for wear, the method of making this adjustment being easily understood by reference to Fig. 79. Within the piston valve is a hollow tapered plug having the same taper as the inside of the valve ring, which can consequently be expanded positively by tightening the set

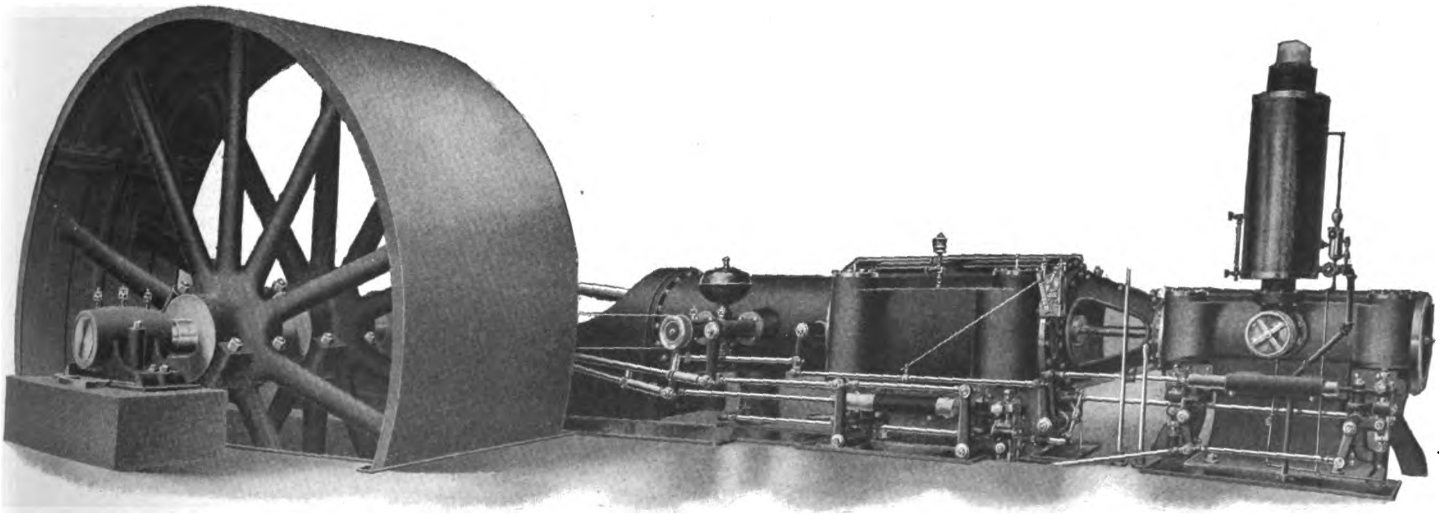


FIG. 75.—C. H. BROWN TANDEM-COMPOUND ENGINE.

screws seen in the back of the valve, which are made accessible by the removal of the back valve chest covers. The governor used on these engines is shown in Fig. 78, from which it will be observed that it is of the combined centrifugal and inertia type. The weights, *W*, *W*, act by centrifugal force to determine the speed at which the engine will run normally, the inertia weights doing the actual governing when changes of speed tend to take place.

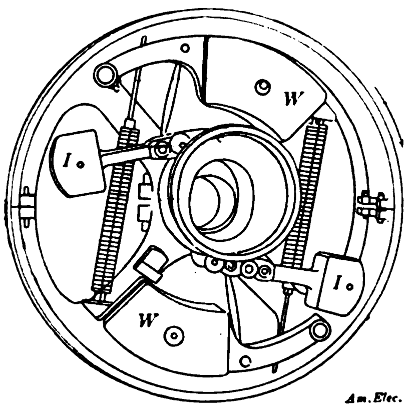


FIG. 78.—FITCHBURG GOVERNOR.

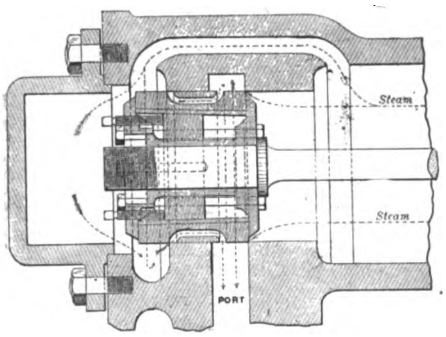


FIG. 79.—FITCHBURG VALVE.

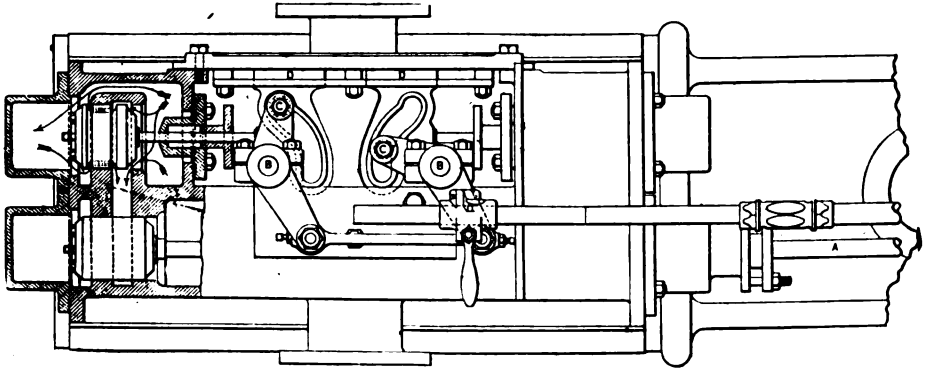


FIG. 80.—VALVE GEAR OF FITCHBURG ENGINE.

Single valve automatic engines for electrical service are also made by this company. They are fitted with a plain slide valve cantrolled by a governor of exactly the same type as that just described, excepting that the eccentric is replaced by a link carrying an eccentric pin. This link joins the points, *B*, *B*.

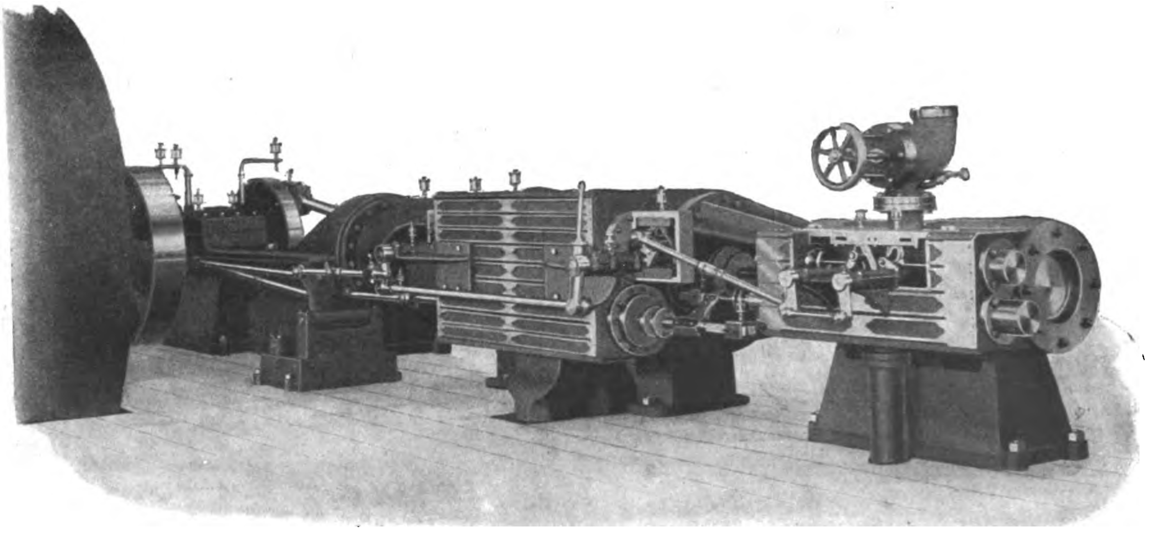


FIG. 81.—TANDEM-COMPOUND FITCHBURG ENGINE.

Harrisburg Medium Speed Engines.

The four-valve tandem-compound engine, shown in Fig. 82, is the product of the Harrisburg Foundry & Machine Company, and is one of this company's line of moderate speed engines. A noticeable feature in the construction of the frame which gives a solid self-contained outward bearing and yet permits reducing the height of the shaft above the floor to a minimum for any given diameter of wheel, consists in leaving the base open in front of the fly-wheel. Rocking valves are used on each cylinder, the admission valves being triple-ported and the exhaust single-ported. These are operated by bell-crank valve gear, the steam and exhaust valves being separately operated.

In the simple engines, the exhaust valves are operated by the exhaust eccentric through the rocker arm, while the steam valves are operated from a separate eccentric and rocker arm by means of bell cranks mounted on arms on the valve bonnets. The short arms of the bell cranks are connected to the valve cranks by short links, while the long arms are connected by a link and receive motion from the rocker arm. This linkage gives rapid opening and closing of the valves, though they move quite slowly while closed and open. All the rods are adjustable by means of right and left hand threads cut on opposite ends, and by the brasses which are moved forward by set screws.

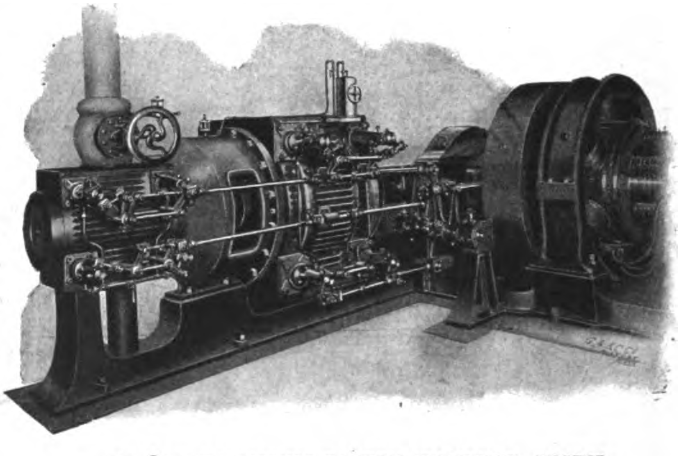


FIG. 82.—HARRISBURG TANDEM-COMPOUND ENGINE.

In the Harrisburg tandem-compound and cross-compound types, the details of construction are practically the same as those of the simple engine just described, excepting the valve-gear which differs in that the linkage used for the steam valves on the simple engine is also used to control the exhaust valves each pair of which receive motion from a separate eccentric; that is, three eccentrics are used. On both the simple and tandem compound engine, the valve eccentric is controlled by the governor, which is of the combined centrifugal and inertia type. The inertia bars are mounted on roller bearings, and all the pins are ground to size and work in bronze bushings. diagonal adjustment of the main bearings is used on these and the automatic engines described farther along.

The oiling throughout these as well as the automatic engines is most profuse. The crank-pin and cross-head run in a bath of oil, some of which is thrown on the piston rod, keeping that also well oiled. Oil collected in a trough is also led to the main bearings, keeping them constantly flooded, the oil being drained back in the crank chamber. A hood and hand-hole covers entirely enclose the running parts and prevent the loss of oil.

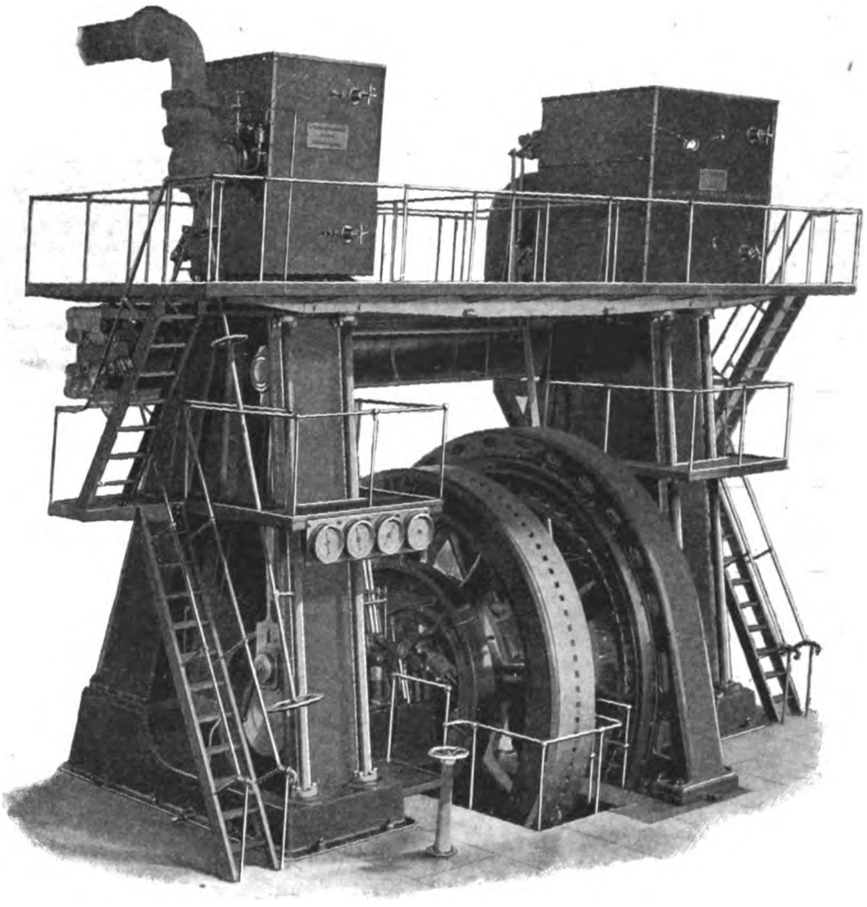


FIG. 84.—M'INTOSH & SEYMOUR VERTICAL COMPOUND ENGINE

Mc Intosh & Seymour Engines.

A substantial form of heavy duty frame engine is that of the McIntosh Seymour & Co., Auburn, N. Y., shown in Fig. 83. Though principally used for moderate speeds, these engines work equally well at low and high speeds. Compactness is one of the noticeable features of this engine, which is also shown in vertical form by Fig. 84. A section through one of the cylinders is shown in Fig. 85. It is unjacketed, but the makers recommend jacketing both the head and barrel of the cylinders of compound and triple expansion engines. Automatic relief valves are fitted to all cylinders, as indicated in the section of the cylinder shown. The heads of the cylinders are made steam tight by a ground fit, without packing, as are the valve seats, which are made separate.

The most striking feature of these engines is the use of four gridiron valves. As shown in the section, Fig. 85, the steam valve has a riding cut-off valve of the gridiron type, which is worked by a separate eccentric and controlled by the governor, while the steam and exhaust valves are operated by a common fixed eccentric. These valves give a clearance space at least as small as that obtained by the Corliss form of valve, require an extremely short travel, and have the advantage that they can be repaired by an ordinary mechanic supplied with a wrench and scraper. The operation of the valve mechanism is as follows: An eccentric keyed to the shaft operating through a rocker arm and link imparts a rocking motion to the shaft, *B*, Fig. 85, which operates the exhaust valve, *V*, by means of a crank and link, and also operates the steam valve, *v*, by the link, *K*, attached to the pin, *P*, on the crank, *P C*. A link from the valve rod, *S'*, to the pin, *P*, imparts the motion to it. The riding cut-off valve, *O*, is operated from the shaft, *A*, which has a rocking motion imparted to it by a rocker and link, connected to the second eccentric; this eccentric is under the control of the shaft governor, to be described presently.

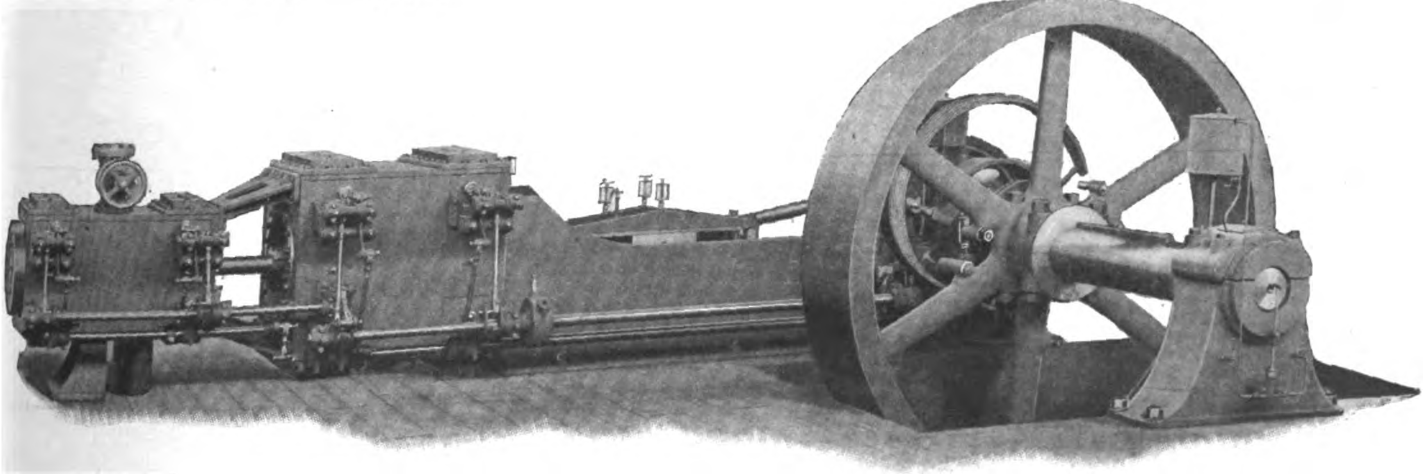


FIG. 83.—M'INTOSH & SEYMOUR TANDEM-COMPOUND ENGINE.

All the rods are adjustable for length between centers and all have bronze boxes adjustable for wear. The bearings of the lay shafts and rockers are also provided with means for taking up wear, of course, and are fitted with grease cups for lubrication. It may be added that because the valve gear is of a very unusual design and is unfamiliar to a great number of engineers, it doubtless appears to be complicated, but on the contrary it is remarkably simple, and having no releasing device it can be worked at any speed desired. Close regulation of the engine over all ranges of load and steam pressure is obtained by an interesting form of centrifugal shaft governor generally mounted directly on the engine shaft, but sometimes mounted on a separate shaft and operated by a drag-link from the crank pin.

Fig. 87 shows the governor in its extreme inner position, giving the maximum cut-off, and Fig. 86 shows it in its extreme outer position, where the steam is practically cut entirely off from the cylinder. When at rest, the centrifugal weights, *B B* and *B' B'*, are held in the position shown in Fig. 87 by the leaf springs, *C C*. These weights are connected each to the governor wheel by a link, *H H*, and to the eccentric, *A*, which is free to move about the shaft, by the links, *G G*. As the speed of the engine increases, the weights, *B B* and *B' B'*, are thrown outward by the centrifugal force, and the links, *G G*, then rotate the eccentric around the shaft in the direction of motion, making the cut-off valve travel more nearly in unison with the steam valve, and thus giving an earlier cut-off. In the extreme position shown, the steam valve is moving in exactly the same phase as the riding valve straddling it, thus entirely shutting off the steam from the cylinder.

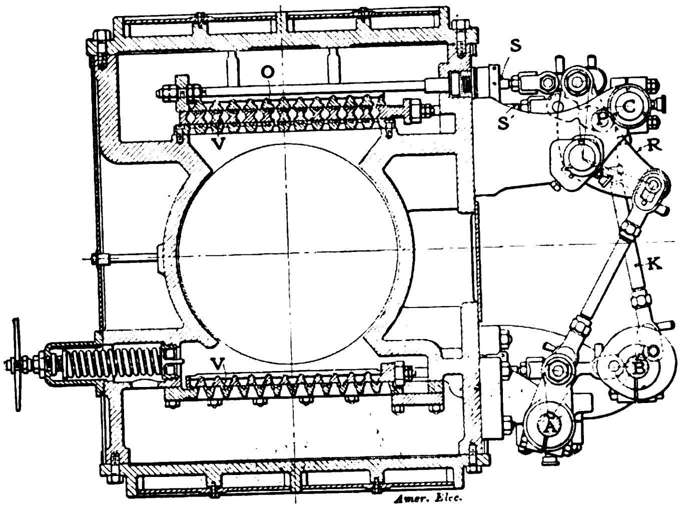


FIG. 85.—DETAILS OF CYLINDER AND GRIDIRON VALVES.

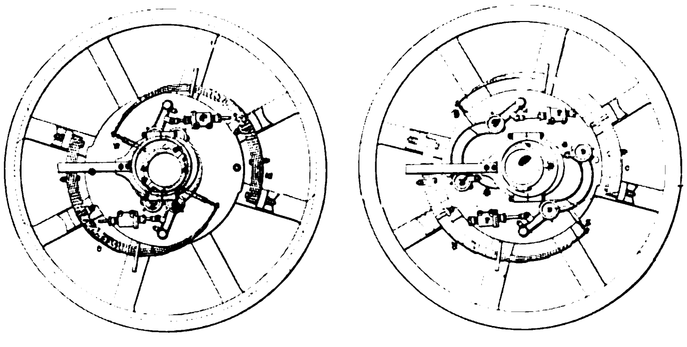


FIG. 86.—DETAILS OF M'INTOSH & SEYMOUR GOVERNOR.—FIG. 87.

Flat guides are used, well supported, and a light form of locomotive type of cross-head is used, having the cross-head pin flattened on the top and bottom to prevent it from wearing oval. In all larger engines, the piston is provided with a tail-rod and a rear cross-head of the "slipper" design, running on very substantial guides. This calls attention to the special method in which the piston rods for this construction are made. Instead of being cambered, they are machined under a force equal to their own weight plus the weight of the piston. When the tail-rod is used, a light form of dished piston made of forged steel is provided, but for the ordinary construction the usual wide piston, with bull rings, is used; in either case, however, only one piston ring is used. For general service the ordinary form of gib-and-key connecting-rod is used, but when preferred the solid head, or marine end, rod is furnished. The main bearings, which are kept flooded with oil by a small pump worked from the valve gear, are made about twice their diameter in length.

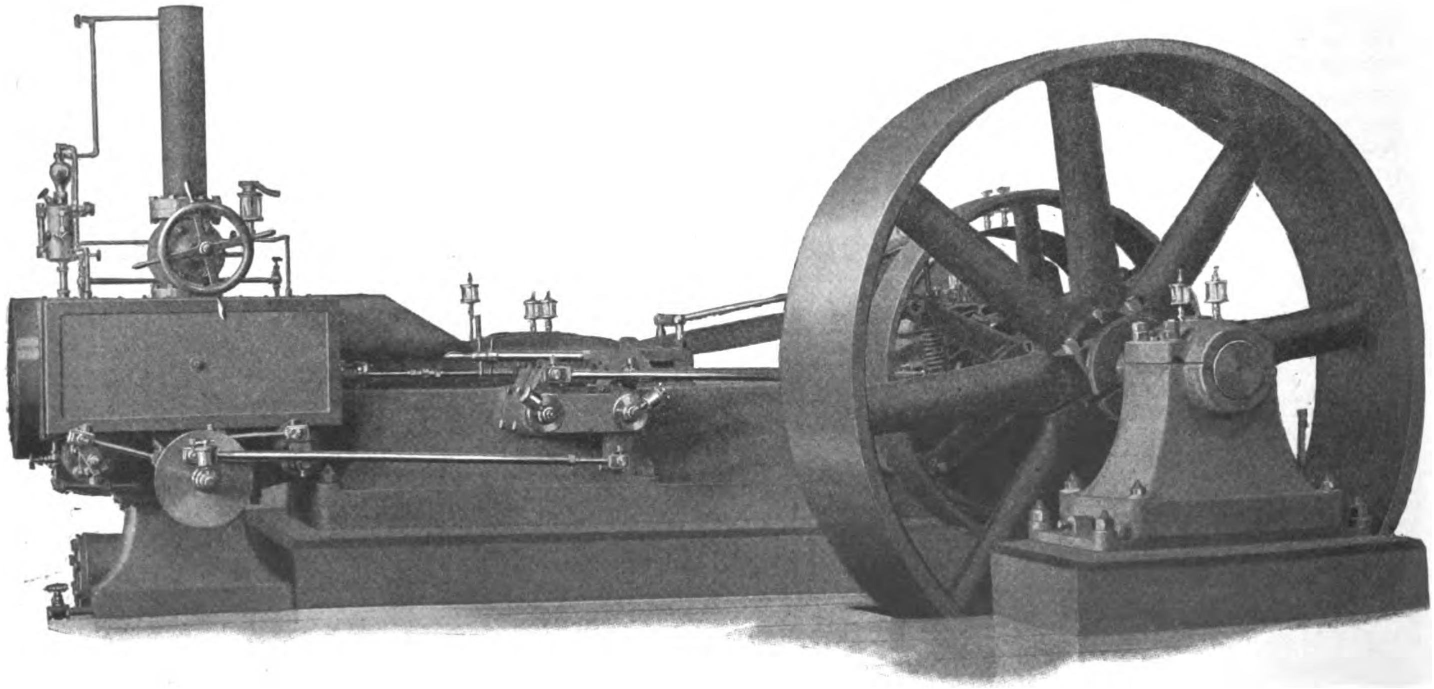


FIG. 89.—RUSSELL FOUR-VALVE AUTOMATIC ENGINE.

Russell Four-Valve Engine.

Another example of four-valve moderate speed automatic engine is shown in Fig. 89, presenting a side view of the engine and valve gear made by the Russell Engine Company, of Massillon, Ohio. A section through the cylinder of a simple engine of this make is shown in Fig. 88, in which the two triple-ported steam valves with the riding cut-off is clearly shown. In order to make adjustment of the lead and cut-off at both ends of the cylinder independently, and also to reduce the weight of the valve, the steam and cut-off valves are made in two parts connected by stretcher rods. As steam is admitted within the valve, nearly all the pressure is balanced. A spring supported pressure plate is provided to prevent the valves leaving their seats. The cut-off valve is worked by a separate eccentric under the control of the governor, while the steam and exhaust valves are operated by a common fixed eccentric. Rotary exhaust valves of special triple-ported variety are used as shown in Fig. 88. An examination of this engraving will show that the large port opening is almost completely uncovered before the others, thus giving a sharp opening to the exhaust, and sharp compression.

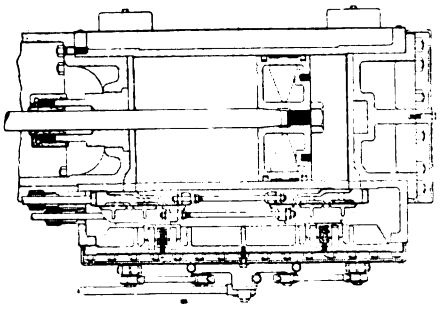


FIG. 88.—CYLINDER OF RUSSELL ENGINE.

Motion of the cut-off valve is transmitted through the rocker farthest from the shaft, receiving its motion from the eccentric on the governor shown in Fig. 91. In the position shown, the cut-off valve would move in such relation to the steam valve that the cut-off would take place at from $\frac{5}{8}$ to $\frac{3}{4}$ stroke. As the engine increases its speed, the governor balls, through the links, turn the eccentric in the direction the wheel is rotating so as to bring it in a position almost coincident with the fixed eccentric, with the cut-off valve straddling the openings, cutting the steam off early, and in the extreme position shutting it off altogether. A novel feature is that of having two eccentrics side by side 180° apart, making it possible to run the engine in the opposite direction by simply reversing the positions of the governor weights and springs. An extremely light cast steel Porter type of cross-head is used secured to the piston rod by a screw nut and lock set screw. It has a wrist pin of large diameter, flattened on top and bottom. The piston, which is hollow, is supported by stiffening ribs and faced with a band of anti-friction metal. The main bearings are made with quarter boxes, all adjustable by screw bolts and wedge for taking up the lateral wear.

A general and a sectional view of the tandem compound engines is obtained from Figs. 92 and 90; the mode of construction used allows the high pressure piston to be withdrawn without disturbing the low pressure cylinder further than removing the heads.

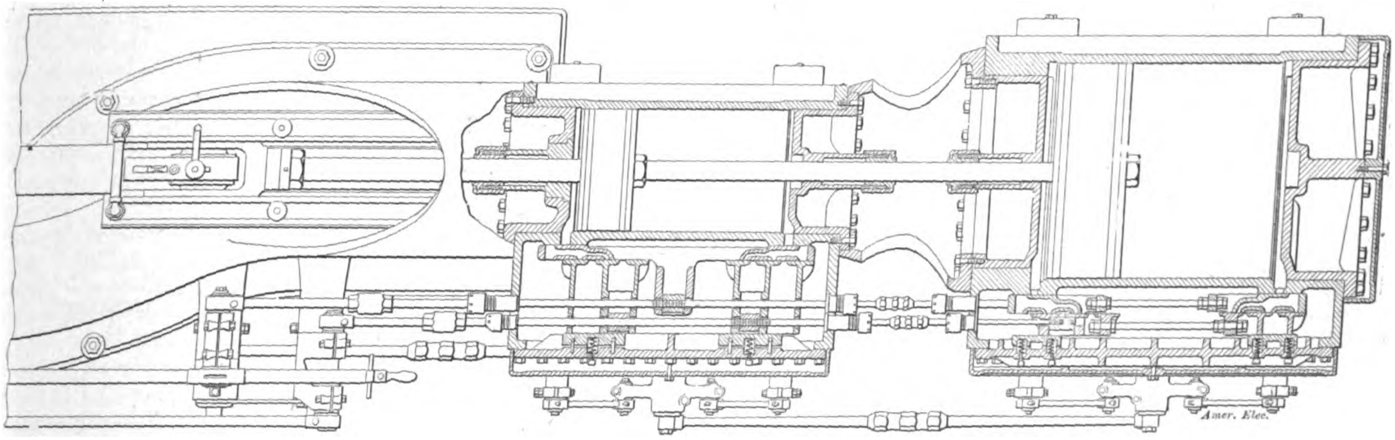


FIG. 90.—SECTIONAL PLAN VIEW OF RUSSELL CORLISS TANDEM-COMPOUND ENGINE.

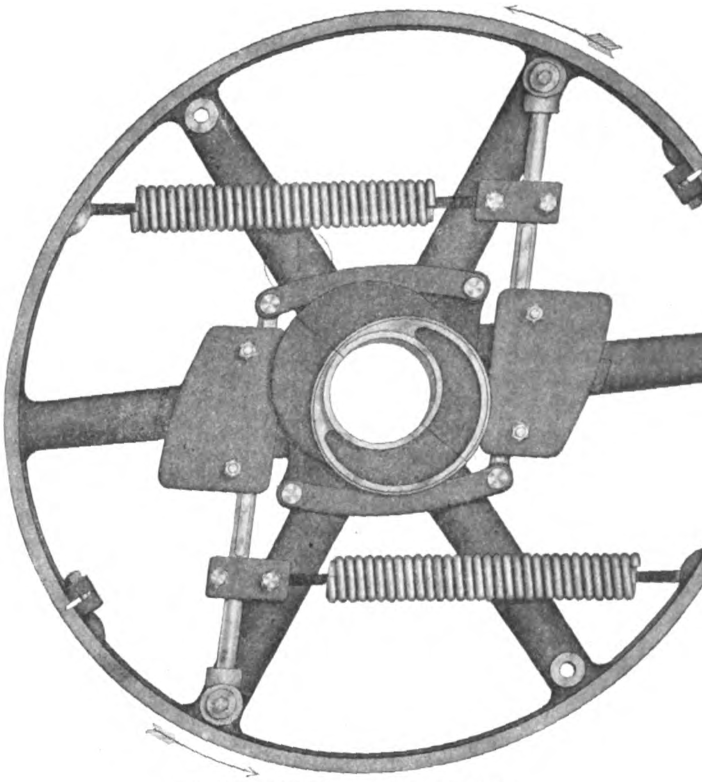


FIG. 91.—RUSSELL SHAFT GOVERNOR.

Williams Medium Speed Engines.

The vertical cross-compound Williams engine made by the Quincy Engine Works, Quincy, Ill., is shown by Fig. 95. The longitudinal vertical section, Fig. 93, illustrates many of the details of the engine.

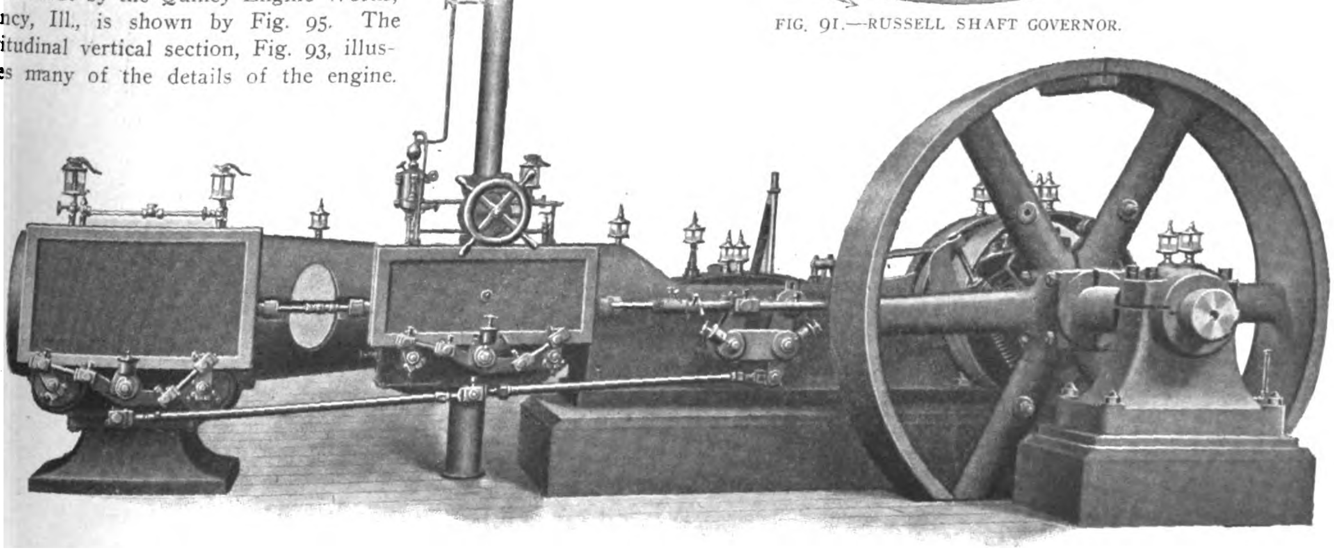


FIG. 92.—TANDEM-COMPOUND RUSSELL ENGINE.

Flat double-ported valves are employed on the high-pressure cylinder. which are made up of two rectangular blocks joined together by a number of hollow stretcher rods of comparatively large diameter, through which the steam can pass from one to the other, giving the double opening which will be observed by reference to Figs. 93 and 96 Only the high-pressure valve is under the control of the governor, which is of a very ingenious design; it changes both the length of valve travel and angular advance. Referring to Fig. 96, the eccentric, *E*, is suspended on the pendulum, *P*, which is free to be shifted across the shaft by the movement of the link, *R*, attached to the governor lever, *L*. The governor wheel is free to rotate about the shaft, and is turned on it by the movement of the link, *R'*, also operated by the governor lever. As the governor lever, *L*, swings, it is evident that since the rod, *T*, does not change in length, the linkage through the bell-crank and rod, *S*, moves the weight, *W*, on the lever, *L*, in such a manner that the centrifugal force and the spring are practically balanced in every position of the governor. Now, from the diagram it is evident that a movement of the lever, *L*, causes the link, *R*, to swing the pendulum and the eccentric across the shaft, and the link, *R′* to rotate the governor wheel on the shaft, thus changing the angular advance of the eccentric. The inertia of the wheel aids in governing.

Multi-ported gridiron valves are used on the low-pressure cylinder and worked by linkage from two eccentrics keyed to the shaft. This valve-gear is shown in Fig. 94, and will be at once seen to be similar to one of those already described, with one or two omissions. The admission valves are worked from one eccentric and the exhaust valve from the other, the system of links and levers being such that the correct motion is imparted to the valves.

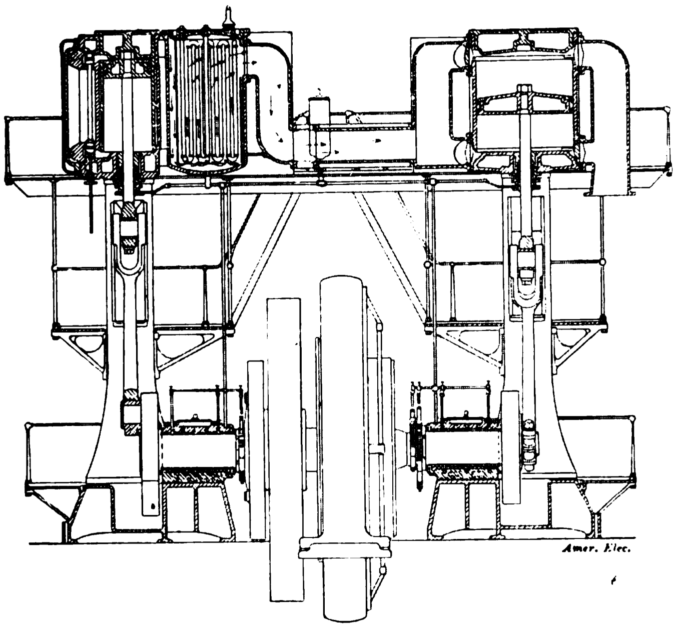


FIG. 93.—SECTION THROUGH WILLIAMS ENGINE.

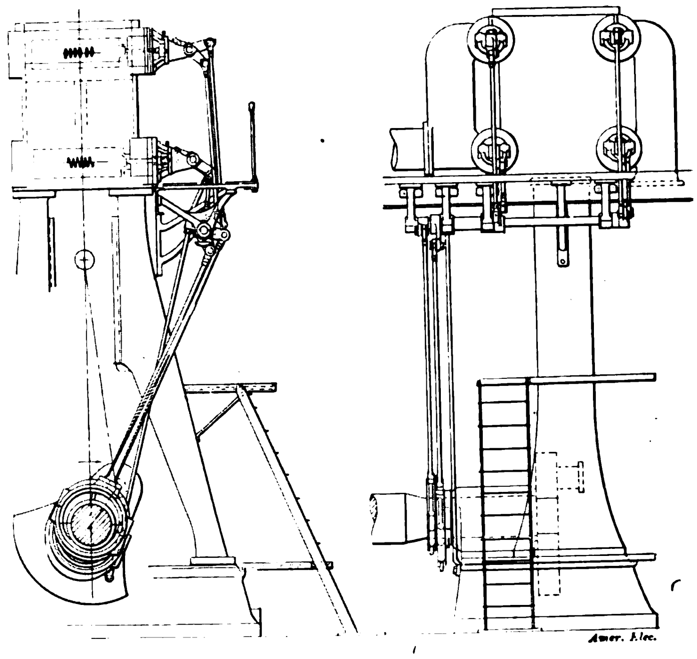


FIG. 94.—LOW-PRESSURE VALVE GEAR, WILLIAMS ENGINE.

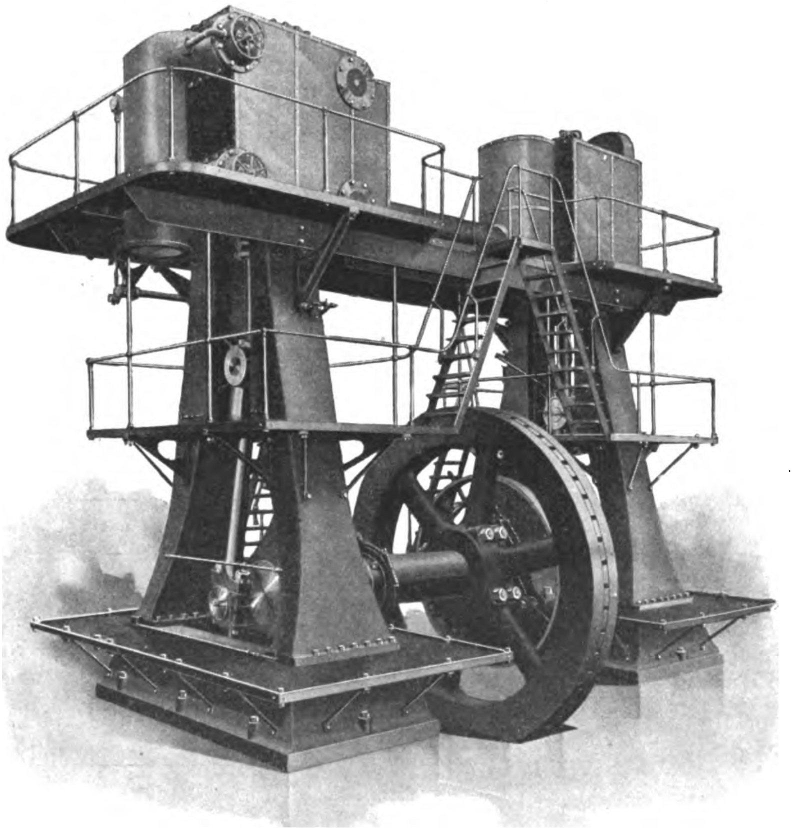


FIG. 95.—WILLIAMS VERTICAL COMPOUND ENGINE.

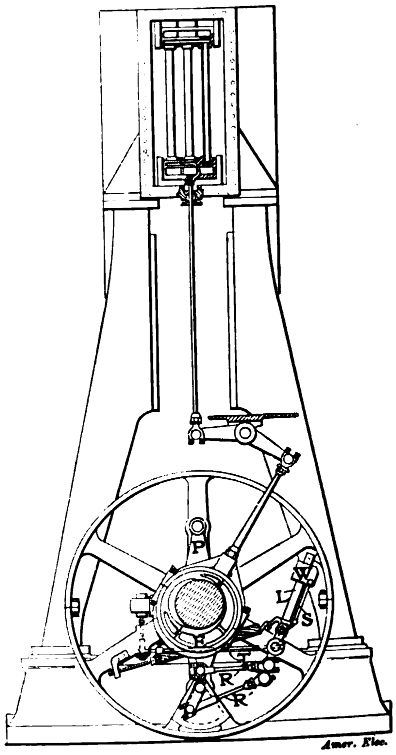


FIG. 96.—WILLIAMS ENGINE GOVERNOR.

HIGH SPEED ENGINES.

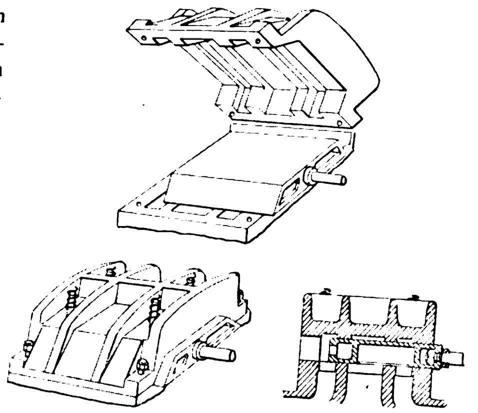
Passing from the medium speed to the high speed automatic engines, one finds that the chief differences between the product of the different manufacturers lie in the design of the valve, valve-gear and governors, which are important in any reciprocating engine, but are of special importance in this class of engines, for it is upon the merits of these parts that the engine chiefly depends. During the past two or three years, the principal development in this class of engines has been in the perfecting of the governing and a greater refinement in the machine work, resulting in quieter and steadier running and greater reliability of operation.

Atlas Slide Valve Engines.

The high speed automatic engine of the Atlas Engine Works is illustrated in Fig. 97, which shows the latest model of this company's high-speed line, which has been re-designed recently. The principal changes made were in the valve-rod guide, the bed, and the governor, which has been made reversible, strengthened and otherwise improved. The valve-rod guide has been changed from the slipper cross-head pattern to two round rods reciprocating in holes bored and reamed to match. The balanced slide valve illustrated in Figs. 99 and 101 has been fully described many times. It may, however, be said that balancing is obtained by admitting steam to recesses in the pressure plate back of the valve, which of the same area as the ports. In Fig. 100 is shown the method of securing the pressure plate in place by four top bolts not screwed home, thus permitting the valve to rise under excess of pressure.

The governor will be seen by an examination of Fig. 102 to be of the balanced centrifugal and inertia type, having the two governor weights attached to rocker arms linked together by rods carrying springs which are in compression. Short shafts keyed to these rocker arms pass through the arms of the fly-wheel and carry on their other ends rocker arms which are in turn linked to the eccentric. To reverse the governor for operation in the opposite direction, it is only necessary to change the governor weights to the other ends of the rocker arms and change the springs to the opposite ends of the connecting links.

The style of cross-head employed on this engine is that which has been used successfully in marine work, namely, the so-called "slipper" type. It is made in one piece with the cross-head pin fitted in with a taper held by a jam nut; the piston rod passes through a hole in the end with considerable play, and is centered by three set screws. It is held in place longitudinally by right and left-hand screws and nuts.



FIGS. 99, 100 AND 101.—BALANCED SLIDE VALVE, ATLAS ENGINE.

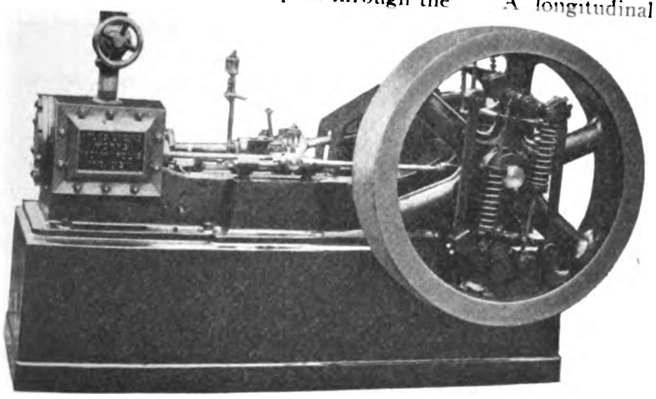


FIG. 97.—ATLAS HIGH-SPEED ENGINE.

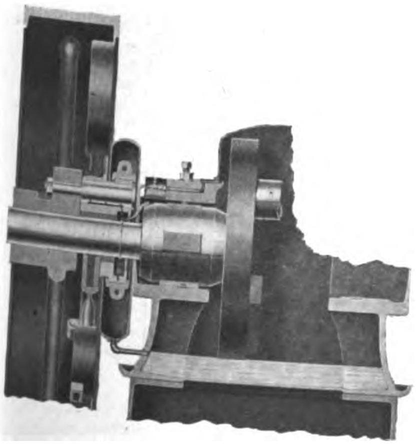


FIG. 98.—ERIE BALL BEARING DETAIL.

Erie Ball High Speed Engine.

A longitudinal section through the cylinder and frame of a simple horizontal engine made by the Ball Engine Company, of Erie, Pa., is shown in Fig. 103. A box type of frame giving support to the guides throughout their entire length, and having the main bearing seats cast in one piece with it, rests on a heavily ribbed cast-iron sub-base. It will be noticed from this illustration that the crank pit is filled with oil into which the crank discs dip, so as to throw it to all parts of the engine. Oil caught in a channel on each side of the crank chamber is led by oil ways to the main bearings, and the arrangement is such that the engineer can see whether or not the bearings are getting their proper supply of oil. Oil rings formed in the sides of the crank discs deliver oil to channels leading to the center of the crank-pin, which is thus kept flooded.

Fig. 104 shows the well-known telescoping valve which is a distinctive feature of the Ball engine, and Fig. 106 shows a vertical section through the center of the valve. The arrangement of the cylinder ports will be easily traced, being shown in dotted lines on both the horizontal and vertical sections. The main feature of this valve is that it is made of two parts, fitting telescopically into each other, and made steam tight by three packing rings. The steam enters the top of the valve and is inside of it, thus forcing the two halves of the valve against their seats with a pressure which remains the same at all parts of the valve travel. The pressure forcing the valve against its seats is just enough to hold the faces tight, so that the valve is easily moved. Motion is imparted to the valve by a loose fitting head (of course it will be understood that there is no play), to which the valve stem is attached, thus obviating all bending strains.

The valve is controlled by a simple form of centrifugal and inertia governor having but two moving parts, the governor weight and the link connecting it to the eccentric. This governor, which is the latest design of the company, is of the combined centrifugal and inertia type, and as in all of these governors, the speed is defined by

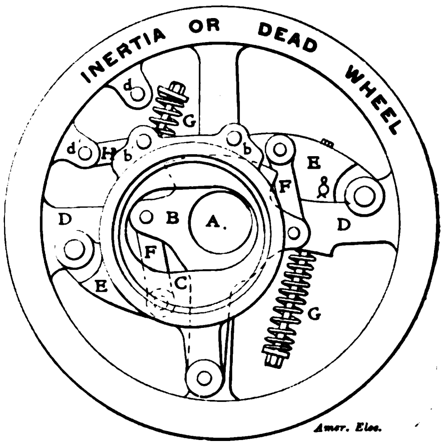


FIG. 102.—ATLAS SHAFT GOVERNOR.

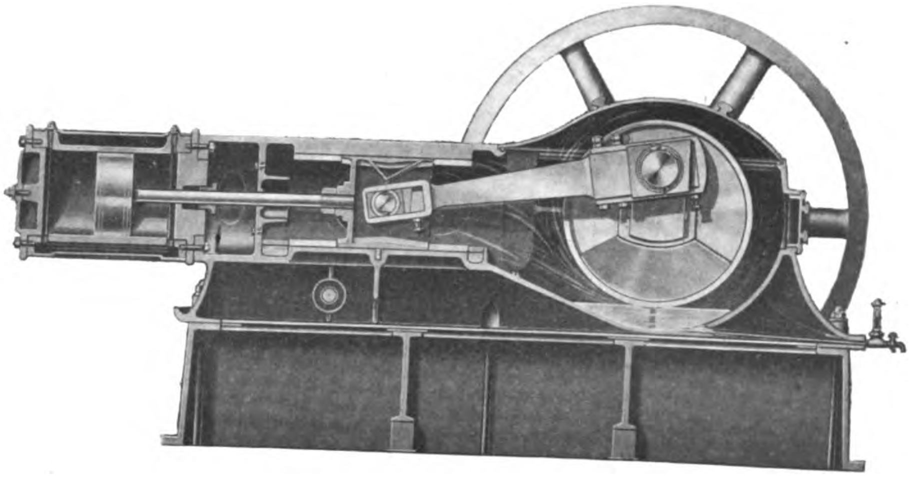


FIG. 103.—LONGITUDINAL SECTION OF ERIE BALL HIGH-SPEED ENGINE.

centrifugal force and the governing is effected by the force of inertia acting tangentially. This governor was fully described on page 70 of the AMERICAN ELECTRICIAN for January, 1903.

Side and center-crank construction is used, and the designs include horizontal and vertical engines of the tandem and cross compound types. Fig. 105 shows the frame of a vertical cross-compound which has the advantages of allowing the removal of the shaft and journal boxes in the simplest manner possible. The housings are bolted together, and have their bases planed in one operation; they rest on a solid one-piece sub-base. Rigidity of the frame is secured by the insertion of heavy struts bolted across the jaws in the frame; the recesses are made just deep enough to allow the centers of the journal boxes, which are held in them, to be set in line with the centers of the cylinders. The top and quarter segments of the main journal boxes the adjustable by three screws in the struts, the lower piece being left free to move transversely, so as to always give the journal a proper seating.

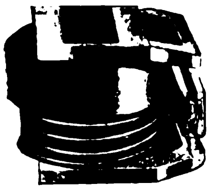


FIG. 104.—VALVE.

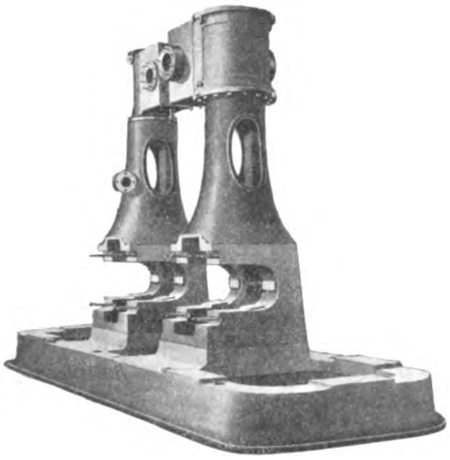


FIG. 105.—FRAME FOR VERTICAL CROSS-COMPOUND ERIE BALL ENGINE.

Ordinary D valves are used on these vertical engines, and the high pressure valve only is controlled by the governor, which is of the same design as that on the horizontal type. The cranks are made in one piece with the shaft machined out of a steel forging, as are also the connecting rods.

Ball & Wood Engines.

Fig. 108 illustrates one of the Ball & Wood Company's automatic high-speed engines, connected to a multipolar dynamo. The lubrication in these engines is secured by the pipe system; that is, all the bearings are supplied with oil from a central reservoir. The valve of this engine in simple form is of the same construction as that used on the Erie Ball engine, both having been designed initially by Mr. Frank H. Ball. On the low pressure cylinders of the compound engine the form of rocking valve shown in Fig. 109 is used. It is made of large diameter, permitting short easy ports, and quick opening to steam is insured by the use of a Trick two-ported valve. The arrows show so clearly its operation that an explanation would be superfluous, though it may be well to say that the valve is practically balanced, there being only unbalanced pressure enough to keep it steam tight.

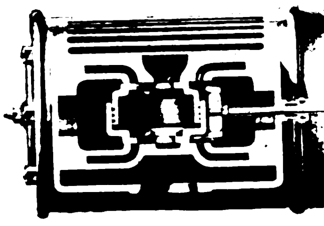


FIG. 106.—SECTION THROUGH VALVE.

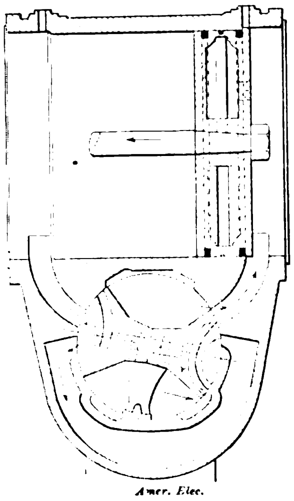

Amer. Elec.

FIG. 109.—BALL & WOOD ROCKING VALVE.

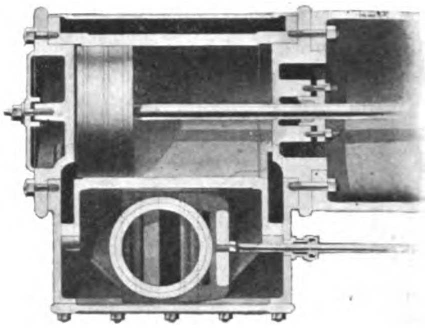


FIG. 107.—SECTION THROUGH CYLINDER AND VALVE OF ERIE BALL ENGINE.

The governor is shown in Fig. 110, and its operation has been described elsewhere in this article. On examination of the wheel it may be observed, however, that the method of securing the wheel in the shaft is by two heavy bolts, and two keys held by set screws. This is on the side of the wheel opposite the governor weights, thus balancing it. Locomotive type guides and cross-head are used. The connecting rod is made of forged steel and is of an improved key and strap type, having adjustable babbitt lined brasses. A solid steel crank-shaft, with counter-balance weights, runs in removable babbitted main bearings.

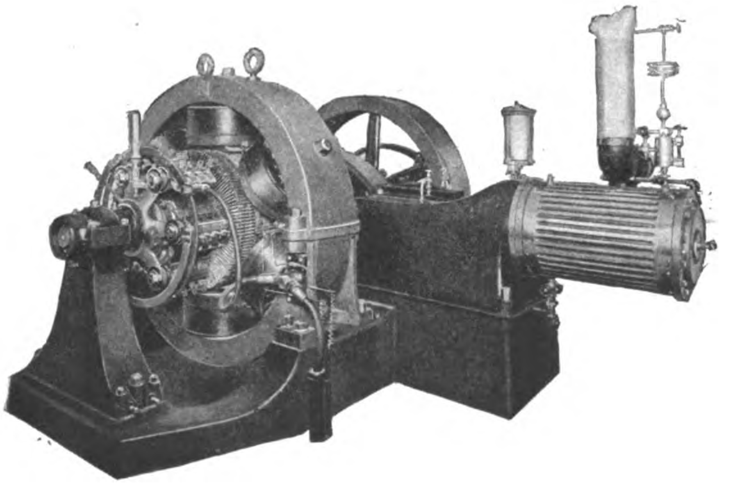


FIG. 108.—BALL & WOOD HIGH-SPEED ENGINE.

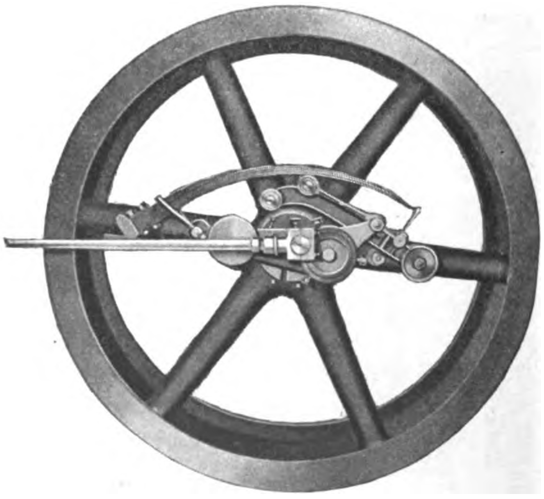
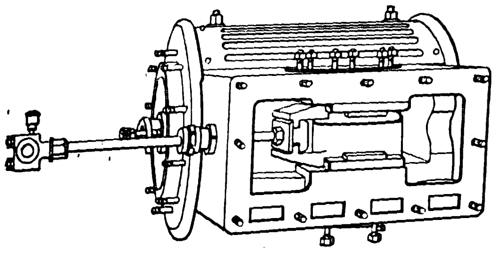


FIG. 110.—BALL & WOOD GOVERNOR.

American Ball Engines.

In the engines of the American Engine Company, Bound Brook, N. J., the piping system of oiling is used, but the oil is forced to the bearings by a small pump worked from the valve gear rocker arm. Valves of the type used on the simple Erie Ball and Ball & Wood engines just discussed are used and further illustrated in Figs. 111 and 112, which show also the studs for bolting the cylinders to the frame, and for attaching the valve chest cover. The cross-head is of the locomotive pattern, and the connecting-rod is of the marine design at the crank-pin end, with the ordinary key adjustment of the brasses at the cross-head end. A solid steel crank-shaft is employed.

The governor has one inertia bar with the spring so attached that little strain is thrown on the suspension pin; this is illustrated in



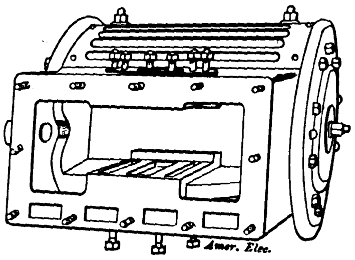


FIG. 111.—AMERICAN BALL STEAM CHEST WITH AND WITHOUT VALVE.—FIG. 112.

Fig. 114. The eccentric pin is moved across the shaft on the arc of a circle by the movement of the inertia bar; the center of this circle is so chosen that the arc is concave towards the center of the shaft. thus giving a maximum lead from no load to full load.

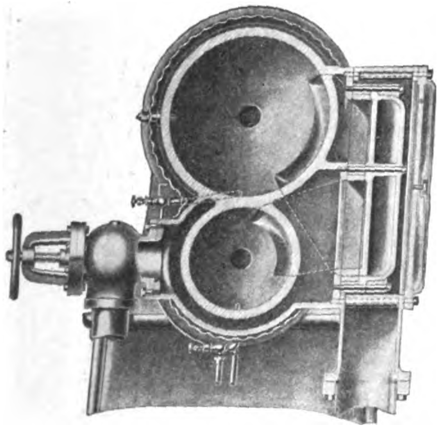


FIG. 113.—TRANSVERSE SECTION THROUGH CENTER OF CYLINDERS AND VALVE CHEST.

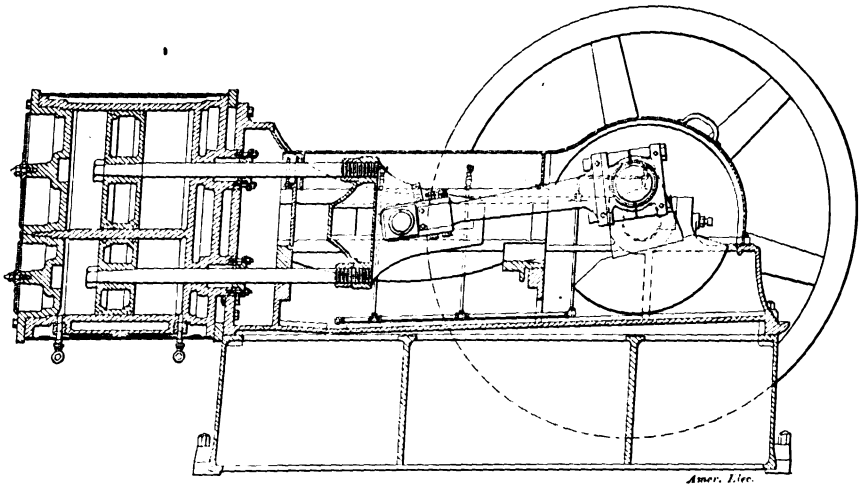


FIG. 115.—SECTIONAL ELEVATION OF AMERICAN BALL DUPLEX COMPOUND ENGINE.

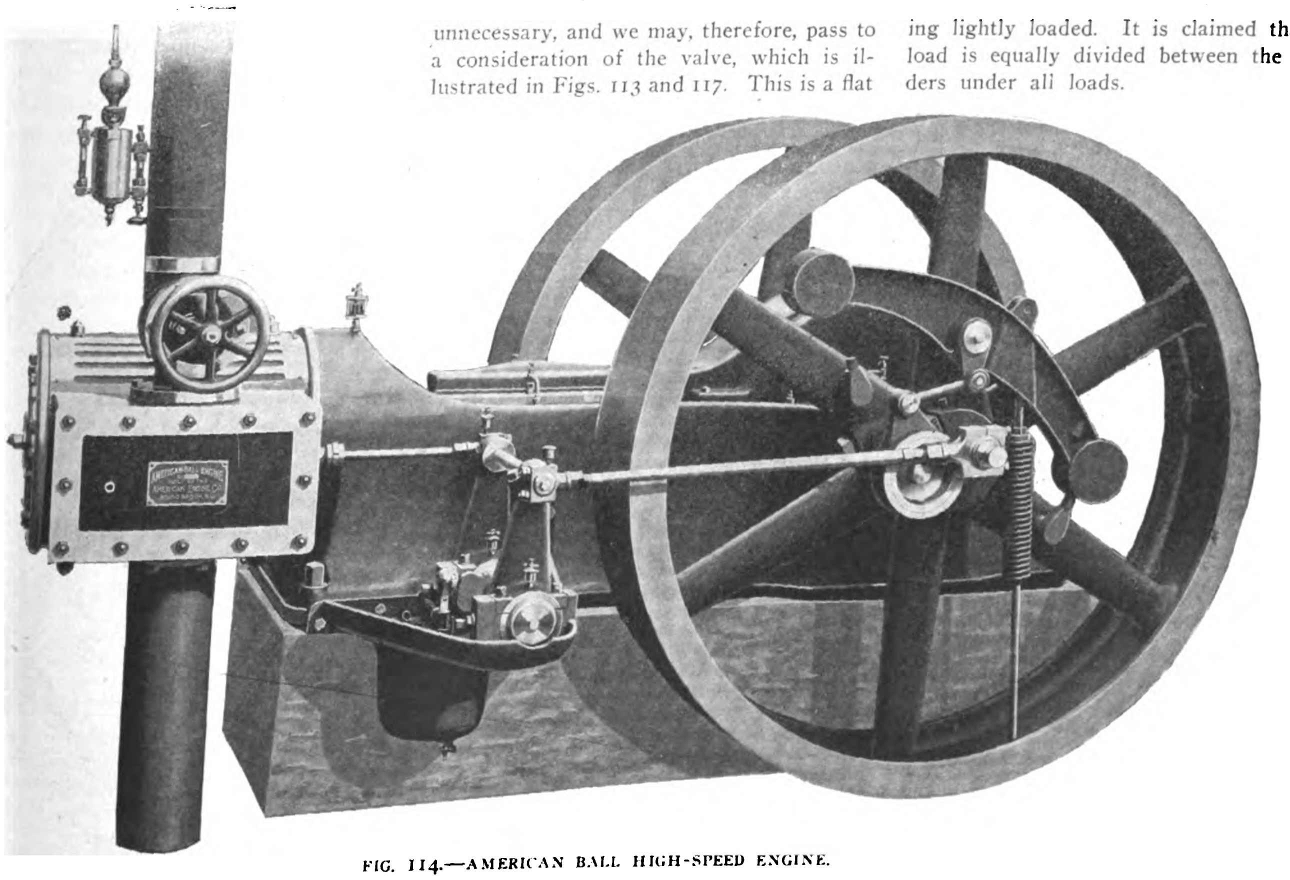


FIG. 114.—AMERICAN BALL HIGH-SPEED ENGINE.

The section shown in Fig. 115 is that of the American Ball duplex compound engine, which is, with the exception of the valve, the counterpart of the Vauclain compound locomotive. The high economy, small floor space and small number of ports are the advantages claimed for this construction. All details of the frame, cross-head, guides, connecting-rods and pistons are so clearly shown in the engraving that explanation is unnecessary, and we may, therefore, pass to a consideration of the valve, which is illustrated in Figs. 113 and 117. This is a flat skeleton frame of uniform thickness, moving between the valve-seat and the valve-cover; the latter is hollow and serves as a receiver between the high and low pressure cylinders.

As will be seen in Fig. 113, the steam before it enters the cylinder encircles it, entering the small valve shown in Fig. 113, which serves as a steam chest. In Figs. 116 and 117, the crank end of the high-pressure cylinder is shown exhausting into the head end of the low-pressure cylinder through the valve-chest cover. Steam is being admitted to the head end of the high-pressure cylinder, and is exhausting from the low-pressure cylinder around the back of the valve-cover. These operations can be easily followed in the drawings by the arrows which mark the direction of the steam. Both the high and the low-pressure valves being in one common piece, both are under the control of the governor, and this accounts for the economy shown when running lightly loaded. It is claimed that the load is equally divided between the cylinders under all loads.

Buffalo Forge Engines.

Figs. 119, 120 and 121 show three of the many varieties of simple, tandem and cross-compound engine for electric lighting purposes manufactured by the Buffalo Forge Company, Buffalo, N. Y., those illustrated in

Figs. 119 and 121 being of the side-crank enclosed type having the reciprocating parts running in oil; an open center-crank type of this engine is also made. A construction is used for the frames of some styles of the side-crank engines having an arm extending out round the fly-wheel from the rear, on which the outward bearing is mounted, thus making it virtually a self-contained engine with the side-crank advantages. This character of construction has been elsewhere illustrated. A simple piston valve is used, which is clearly shown in Figs. 119 and 120, which also show the cylinder and frame design. The governor is of the centrifugal shaft type, and has a curved weight arm moving the suspended eccentric pendulum across the shaft by a link. This is clearly illustrated in Fig. 119. The curved arm carrying a sliding weight is the special feature in that adjustment for speed can be easily made in a short time by simply moving the weight to the position giving the desired speed. Additional adjustment can be made, of course, by altering the tension on the spring. Hollow pistons and box type cross-heads are used, both attached to the piston rods by screw and nuts. A closed end is employed on the cross-head end of the rectangular connecting rod, and a strap with screw and wedge adjustment at the crank-pin end.

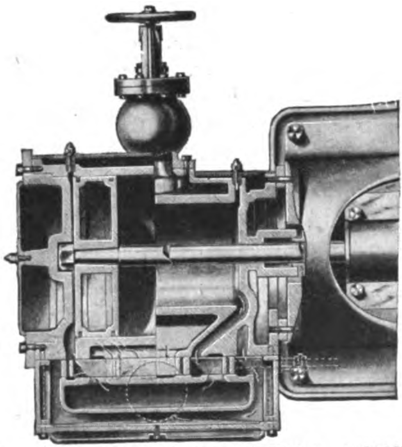


FIG. 116.—HORIZONTAL SECTION THROUGH HALF OF LOW-PRESSURE AND HALF OF HIGH-PRESSURE CYLINDERS.

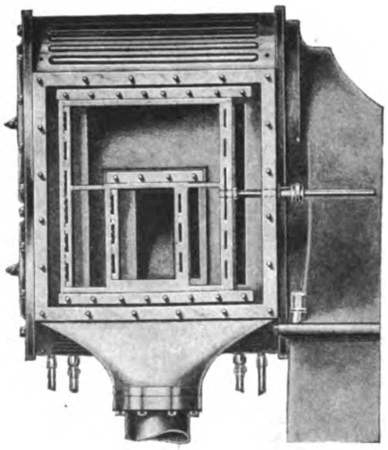


FIG. 117.—SIDE ELEVATION WITH VALVE COVER AND STEAM CHEST COVER REMOVED.

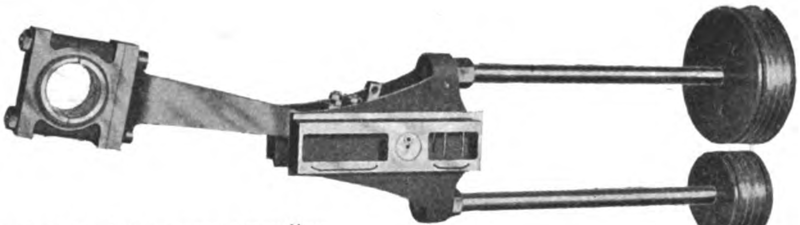


FIG. 118.—AMERICAN BALL PISTONS AND CROSS-HEAD.

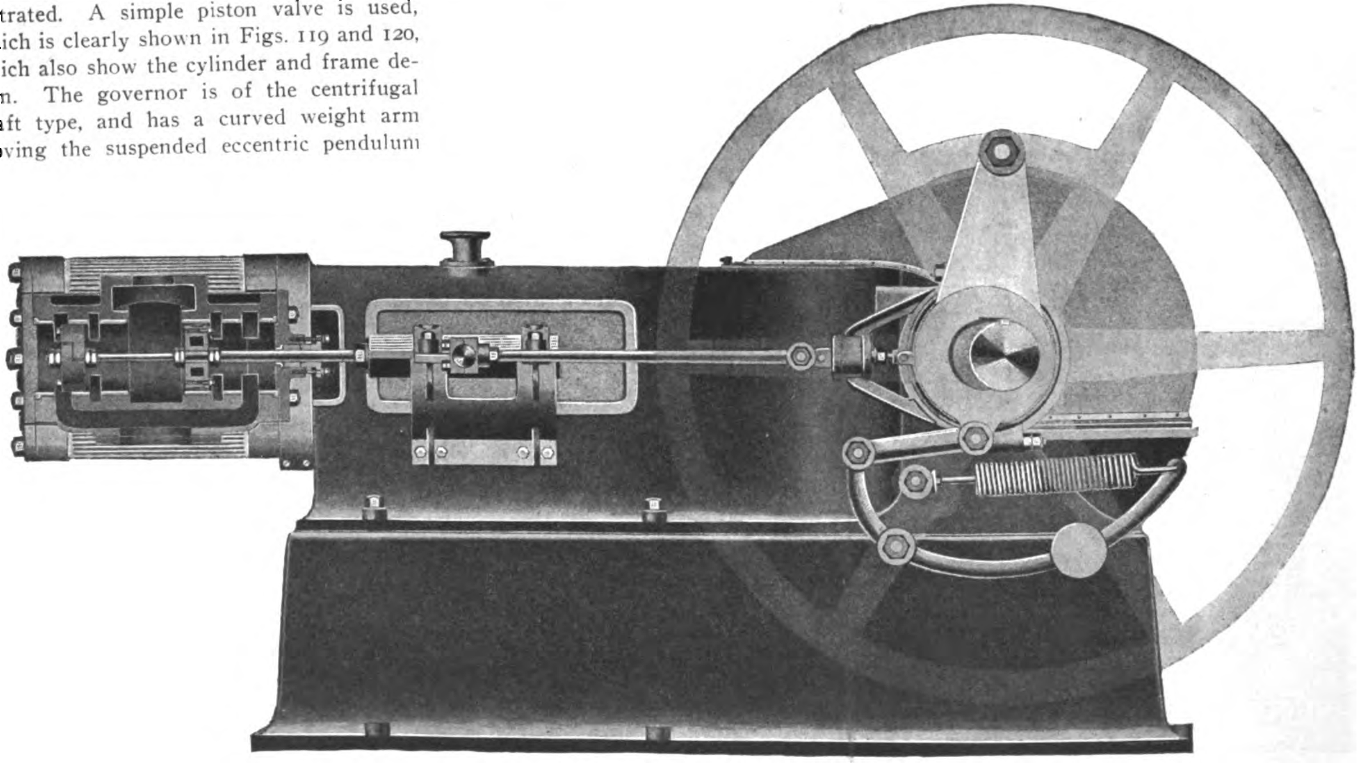


FIG. 119.—VERTICAL SECTION SHOWING VALVE AND VALVE GEAR OF BUFFALO FORGE ENGINE.

Buckeye Engines.

A rear view of a Buckeye heavy duty tandem compound engine is shown in Fig. 122, illustrating the system of lubrication by sight feed oil cups and the use of two eccentrics for operating the valve mechanism. Fig. 123 is a section through the cylinders and valve chests of the same engine, showing the use of piston valve for the high pressure, and the flat valve for the low pressure steam distribution. The flat balanced slide valve with an internally riding cut-off is shown on an enlarged scale in Fig. 125, in which *J* is the hollow box main valve, with-

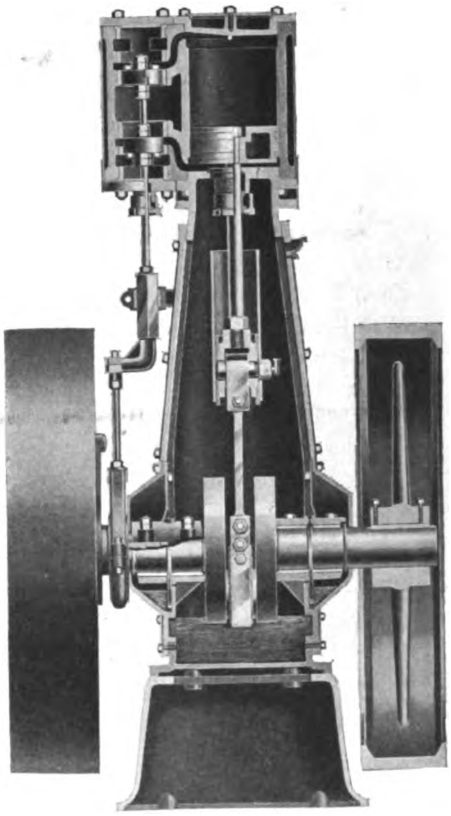


FIG. 120.—BUFFALO FORGE VERTICAL ENGINE.

in which operates the cut-off valve consisting of two plates, *c, c,* joined by two rods, *e.* Steam enters the hollow valve from the steam chest, *a, a,* through four round plates, *d,* which ride on the seats, *s,* on the back of the main valve. The spring, *E,* holds the plates, *d,* against the seats with sufficient force to make them wear properly. So far the valve is perfectly balanced except for the area of the steam port, and to balance this at all points of the travel balancing channels, *f,* are provided at each end, which communicate with the inside of the main valve. To prevent any unbalancing that might be produced by the valve becoming cut or worn near the edges of the ports, grooves, *e,* are cut at such a distance from the opening that the area included between it and the ports is equal to the area of the balancing valves at that end.

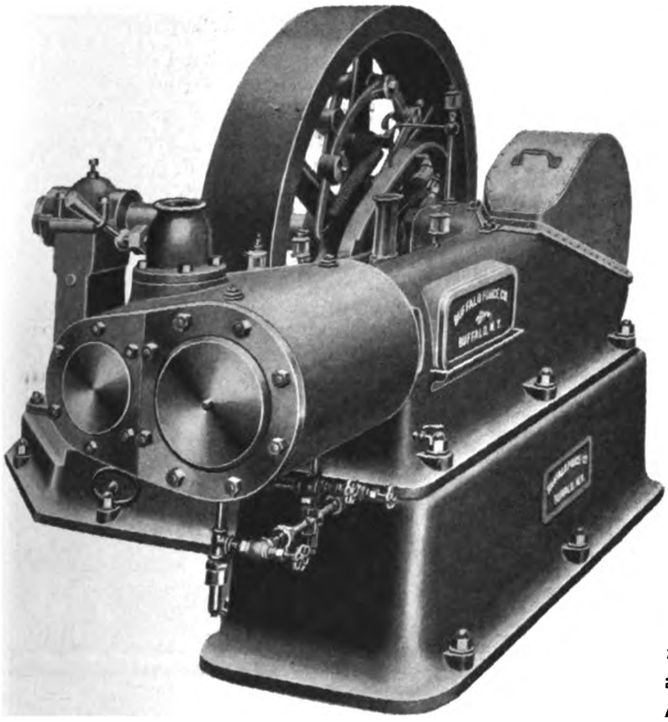


FIG. 121.—END VIEW OF BUFFALO FORGE HORIZONTAL ENGINE.

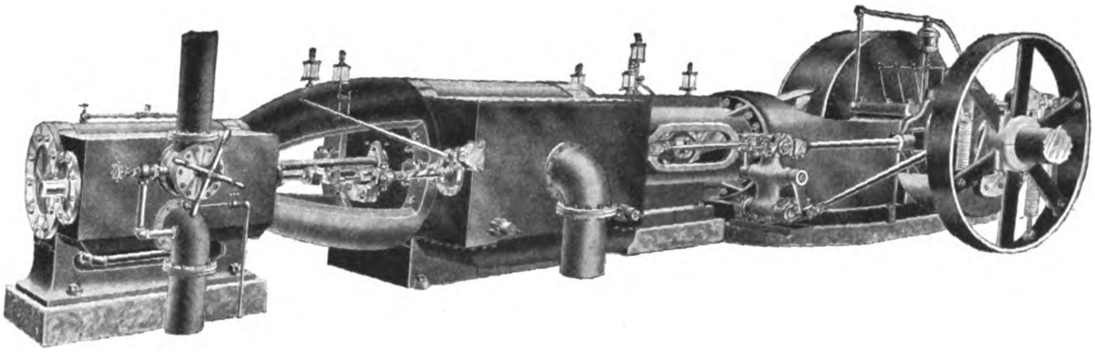


FIG. 122.—BUCKEYE HEAVY DUTY TANDEM-COMPOUND ENGINE.

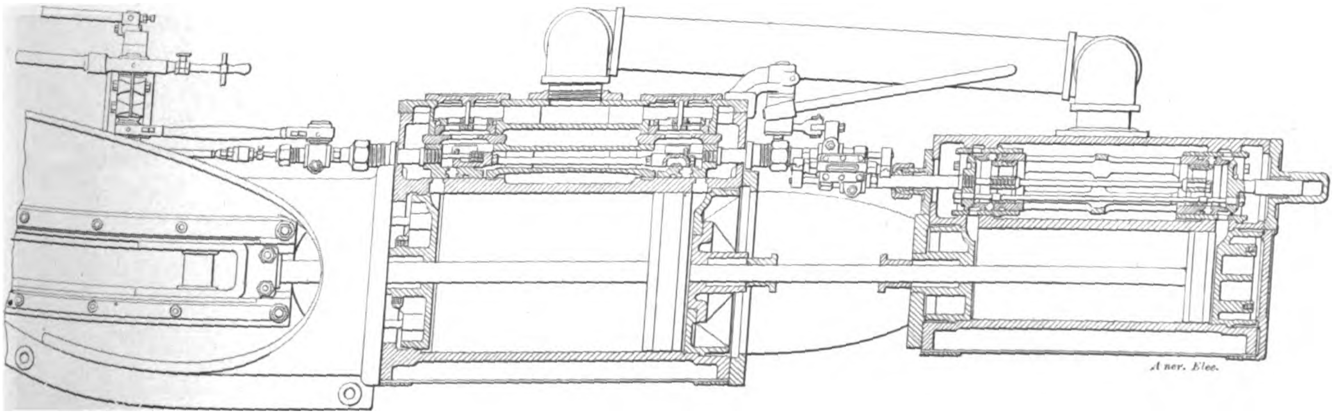


FIG. 123.—SECTION OF CYLINDERS AND VALVE GEAR OF BUCKEYE TANDEM-COMPOUND ENGINE.

As may be inferred, the main and cut-off valve rods are concentric, and the main valve is driven from a fixed eccentric while the cut-off valve is operated from the eccentric under the control of the governor. The piston valve used on the high-pressure cylinder is of exactly the same form, except that, being cylindrical, it is simpler in not having the round balancing plates and balancing grooves. Its construction is shown by Fig. 127, which will be readily understood without description. The arrows indicate its operation. In the centrifugal shaft governor shown in Fig. 126, the weights, *A, A,* act against the force of the springs, *F, F,* when the wheel is up to speed, and their movement through the agency of the links, *B, B,* causes the eccentric, *C,* to rotate around the shaft, *S,* which accomplishes the desired regulation at the valve. The auxiliary spring, *P, P,* are introduced to act on the arms in opposition to the main springs, *F, F,* so as to afford closer regulation with light, varying loads. These springs act only during the inner half of the range of movement of the arms, being thus out of contact with them during the outer range of positions.

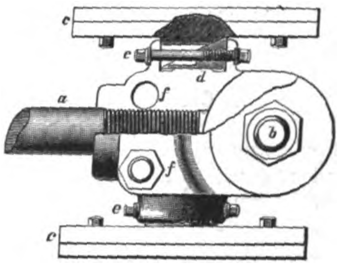


FIG. 124.—BUCKEYE CROSS-HEAD DETAIL.

The method of adjusting for wear of the cross-head used with the girder type engines is illustrated in Fig. 124. A slanting projection on the shoe is turned to fit into a socket of corresponding diameter and slant, found in the cross-head proper. It is expanded by tightening a top bolt fitted with a jam nut on the end. The main or central portion is made in halves which pinch the thread on the piston rod, prevent-

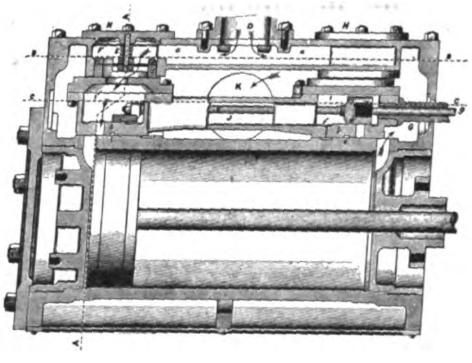


FIG. 125.—CYLINDER OF BUCKEYE ENGINE.

ing its getting loose. There are many other interesting features of this engine which must, however, be omitted because of lack of space. The engine is manufactured by the Buckeye Engine Company, Salem, Ohio.

The Case Engine.

A unique example of automatic high-speed engine construction is presented in Figs. 128 and 129, which illustrate the bracket and the pedestal forms of engine built by the New Britain Machine Company, New Britain, Conn. Still another form is made, which is termed the hanger type because the engine is suspended from the ceiling. These engines are of the very high speed class, running at speeds varying from 550 in the 25-h.p. size to 900 in the 2½-h.p. size. They are much used for direct connection to small dynamos. The maintenance of these high speeds is practicable because there is but one reciprocating part—the piston and piston-rod—the machine being in reality an ingenious form of oscillating engine. The piston and piston-rod of the 2½-h.p. engine weigh together but 3½ pounds, and 11 pounds in the 25-h.p.; in each case, half of this is counter-balanced by the usual counter weights.

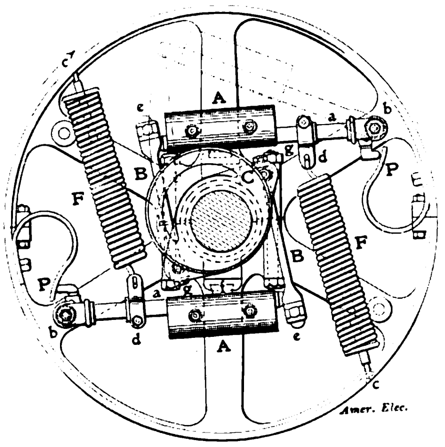


FIG. 126.—BUCKEYE ISOCHRONAL GOVERNOR.

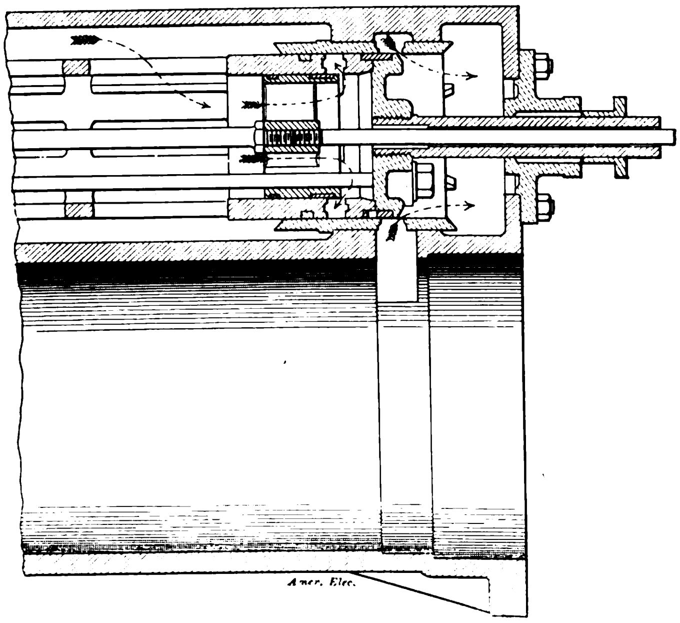


FIG. 127.—PISTON VALVE OF BUCKEYE ENGINE.

As will be seen in Fig. 129, the cylinder consists of a cylindrical piece of cast-iron equal in diameter to the length of the stroke and having a hole bored transversely through it of the same diameter as the piston. This is open at one end, the other end being closed by the case within which it rocks, and it has on it a long piston rod gland and packing box. The case serves as a cylindrical cover for the head end, hence there is no thrust on the cylinder itself during the downward stroke. In order to have no thrust during the up-stroke, steam is admitted to a thin recess in the bottom of the cylinder casting, hence the thrust of the piston is steam balanced continuously, allowing the cylinder to rock freely.

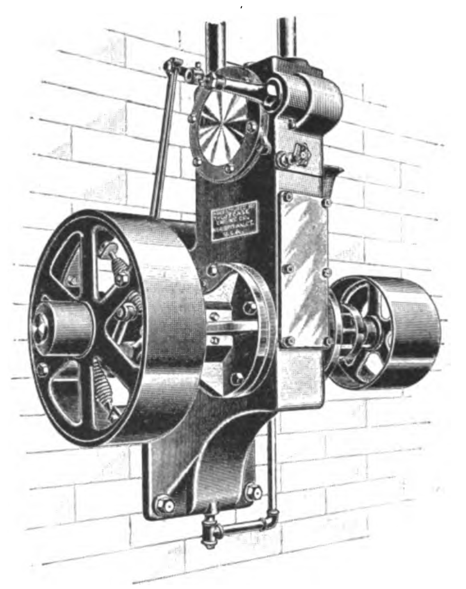


FIG. 128.—CASE AUTOMATIC BRACKET ENGINE.

The valve worked by the eccentric under the control of the centrifugal shaft governor serves only to define the point of cut-off, all the other functions being performed by the cylinder itself, which is practically a rocking valve of large diameter. The governor consists of two weights acted on by centrifugal force in the usual manner, but do not control the engine by varying the travel of the valve, simply rotating it around on the shaft, increasing the lead angle and varying the point of cut-off.

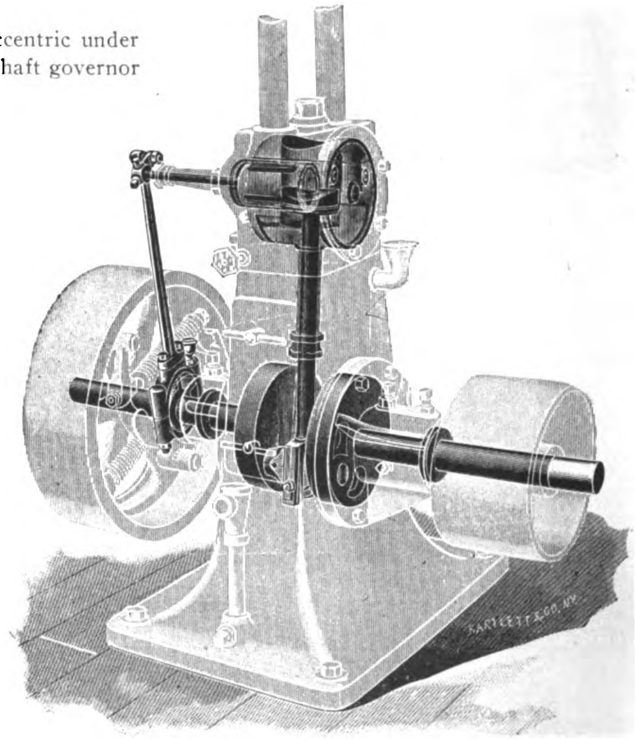

BARTLETT & CO. N.Y.

FIG. 129.—CASE AUTOMATIC PEDESTAL ENGINE.

Chandler & Taylor Engines.

It is to be regretted that detail illustrations of the new class of engines built by Chandler & Taylor Company, Indianapolis, Ind., in accord with the specification of the A. S. M. E. and A. I. E. E. for direct-current units, are not available; we present, however, a description of their standard side-crank belted type, illustrated by Fig. 134. The principal features shown in this illustration are the lubricating system, consisting of a centrally located oil tank connected to all parts needing lubrication by piping, the self-contained shaft governor and the design of the engine bed, which is extended to give support to the outboard bearing, thus combining the advantages of the side-crank engine with those of the self-contained center-crank variety. A more detailed view of the bed is shown in Fig. 131, in which it will be seen that the guides have solid support and are of the bored

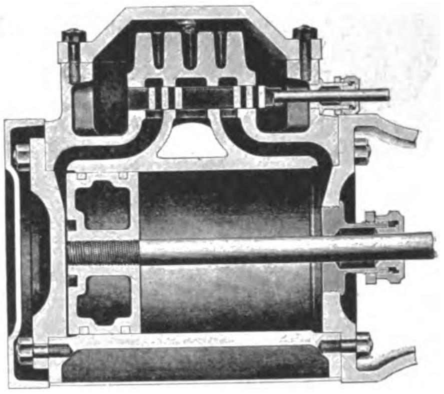


FIG. 130.—CHANDLER & TAYLOR DETAILS.

type, while the diagonally divided main bearing seats have recesses cut in them to permit the use of oil rings. Figs. 132 and 133 illustrate the method of adjusting the journal box. Two conical babbit sleeves are cut into strips lengthwise and held within shorter sleeves screw-threaded on the outside and bored to the same taper; these screw sleeves are held from turning but are free to be moved endwise by the nuts within, which they work. It is evident that the internal diameter of the babbit sleeves may be varied by turning these nuts, which is accomplished by inserting a rod through slots in the bearing cap provided for that purpose.

The slide valve used on this engine is of the multiported or gridiron type shown by Fig. 130. The cross-head is of the box type with babbitt-lined adjustable shoes. The connecting rod is of the rectangular form favored for high speed work, having solid ends and wedge and screw adjustment.

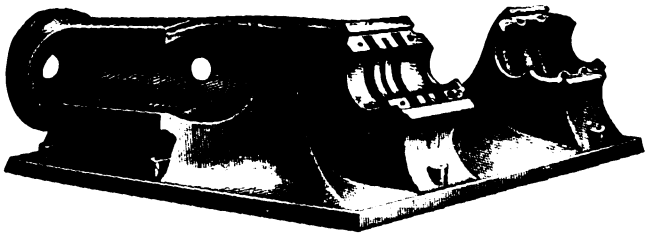


FIG. 131.—CHANDLER & TAYLOR ENGINE FRAME.

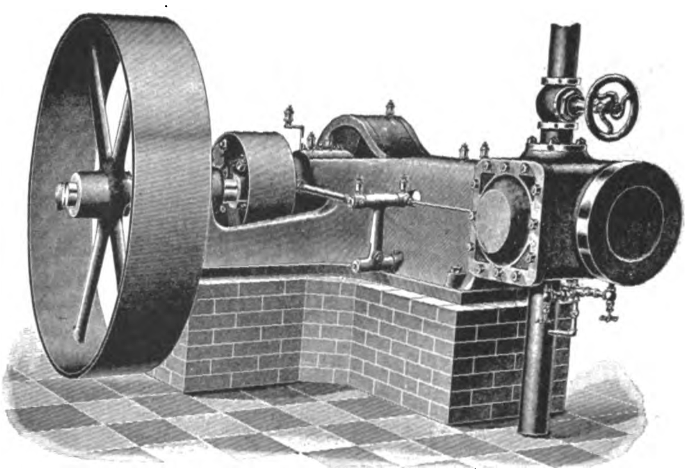


FIG. 134.—CHANDLER & TAYLOR AUTOMATIC CUT-OFF ENGINE.

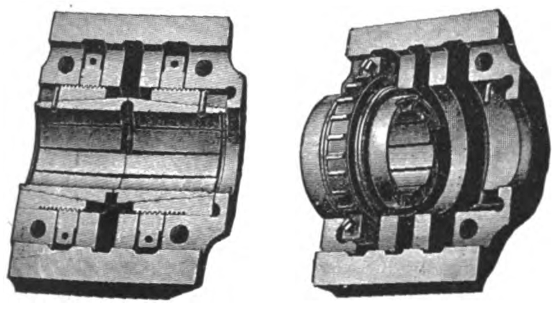


FIG. 132.—CRANK SHAFT BEARING.—FIG. 133.

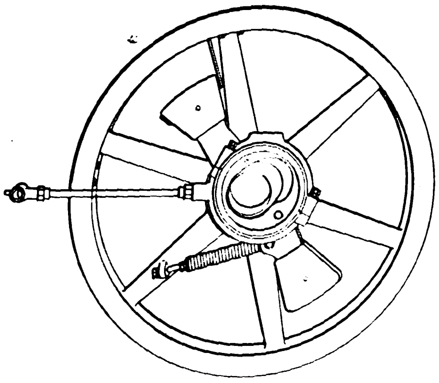


FIG. 135.—CHANDLER & TAYLOR WHEEL GOVERNOR.

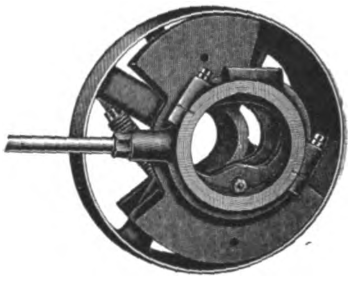


FIG. 136.—SELF-CONTAINED GOVERNOR.

Two different forms of Rites governor are used, one of the fly-wheel type shown in Fig. 135, and the other of the self-contained design illustrated by Fig. 136. The latter is used on the side-crank engines with overhung fly-wheels.

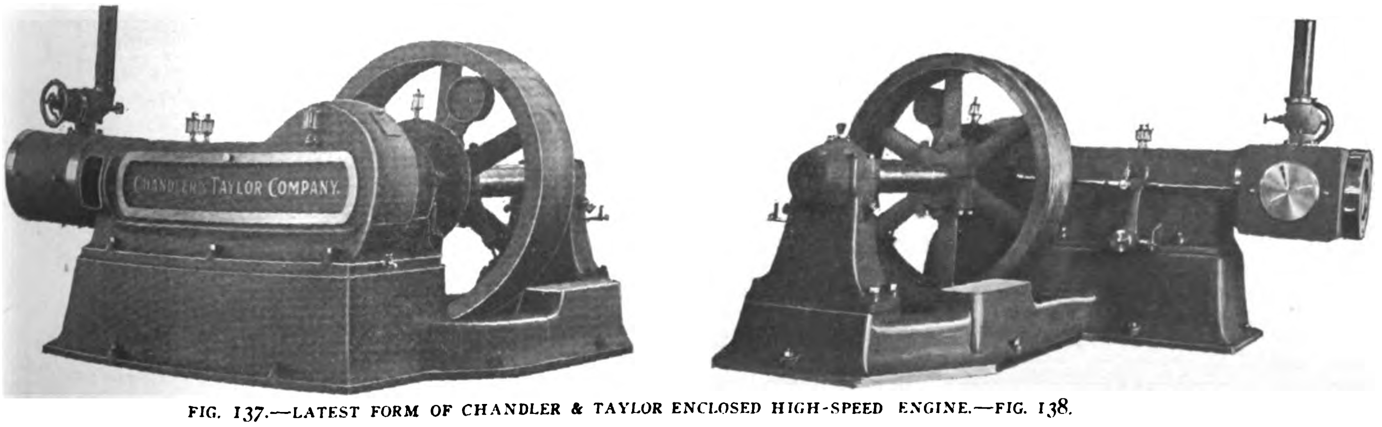


FIG. 137.—LATEST FORM OF CHANDLER & TAYLOR ENCLOSED HIGH-SPEED ENGINE.—FIG. 138.

Figs. 137 and 138 show the latest form of enclosed high-speed engine built by the Chandler & Taylor Company for the direct driving of electric generators, from which it will be evident that the side-crank construction and outboard bearing mounted on an extension of the base have been retained. Most of the other details of construction are also identical with those just described in connection with the open type of engine. The Rites type of governor is used, and the valve is a flat multi-ported slide. As Fig. 138 shows, provision has been made for mounting the generator field magnet on the extension of the engine base, the armature being forced on the projection of the crank shaft between the main and outboard bearings. The simple, massive appearance of the engine impresses one at first sight.

Harrisburg Standard Engine.

The Harrisburg Standard automatic engine is represented in Fig. 139, which shows it to be of the enclosed self-oiling type, the bearings, guides, connecting-rod and eccentrics being lubricated by the oil thrown up by the crank discs. Additional oiling of the eccentric is provided by a sight-feed oil cup. Oil rings on the shaft and a guard around the eccentric catch all oil that is thrown from them and return it to the crank pit. Simple piston valves, taking steam at the middle and exhausting from their outer edges, are used; these work in chilled cast-iron bushings. The exhaust passages are in a Y-shaped casting, made separately and bolted to the cylinder. On engines under 14 inches stroke, a connecting rod with a locomotive-type crank end is used, but on the larger sizes the marine type is employed.

The main bearings have babbitt liners with the cap fitting diagonally, thus taking up the wear in the proper direction, though in the larger engines the customary adjustable quarter-box construction is used. Because of the greater accessibility, greater ease of adjusting two bearings than three, saving in first cost and less danger of breaking the crank shaft, the makers of this engine suggest the use of the side-crank type, though they build both varieties.

Ide Engine.

The engine shown in section in Fig. 141 is that built by A. L. Ide & Sons, Springfield, Ill. Lubrication of all the working parts outside the cylinder and chest is secured by having the crank discs run in a bath of oil contained in the crank pit. Oil is supplied to the crank pin by centrifugal force and to the eccentric and main bearings by ducts leading from a collecting trough in the upper part of the hood. The form of the frame is clearly shown in the drawing which indicates the solid support given to the guides and the separating partition, which permits examining the stuffing box without lifting up the hood.

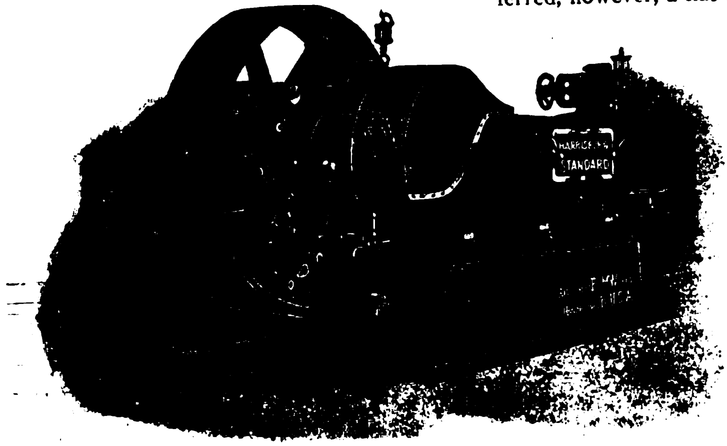


FIG. 139.—HARRISBURG STANDARD ENGINE.

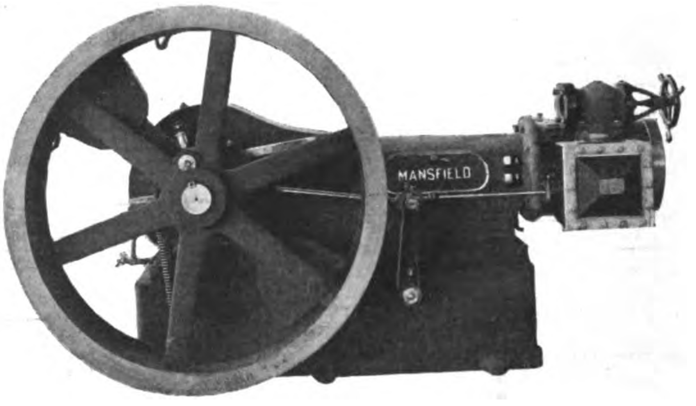


FIG. 142.—MANSFIELD HIGH-SPEED ENGINE.

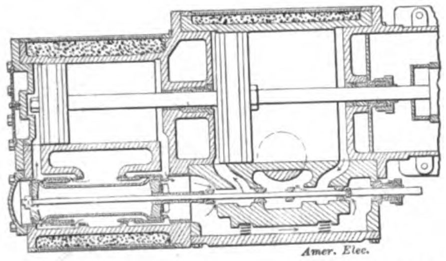


FIG. 140.—SECTION THROUGH IDE TANDEM-COMPOUND CYLINDERS AND CHESTS.

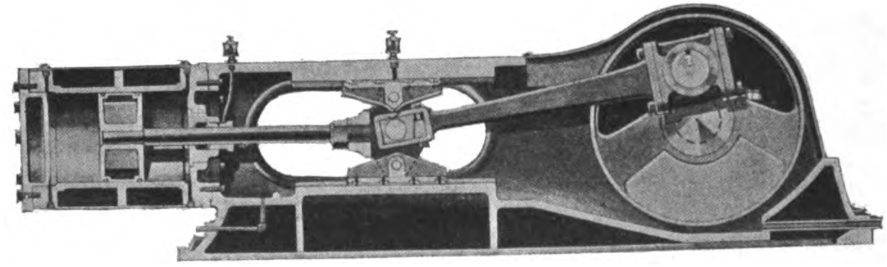


FIG. 143.—LONGITUDINAL SECTION THROUGH M'EWEN ENGINE.

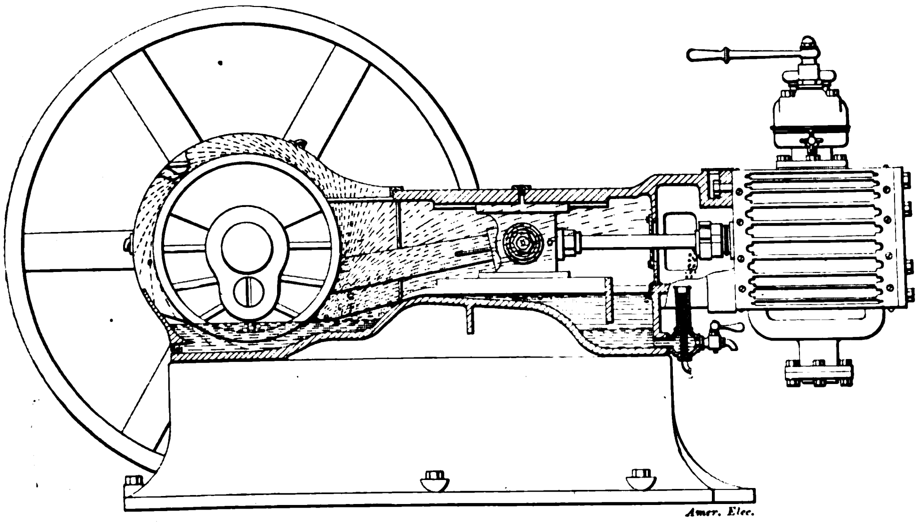


FIG. 141.—LONGITUDINAL SECTION OF IDE HIGH-SPEED ENGINE.

These engines are made single and tandem compound; the simple engines are ordinarily fitted with either plain or patent adjustable piston valves, the latter being capable of adjustment for wear without removing them from the valve chamber. If preferred, however, a flat balanced valve is furnished, and this type is always used on the low-pressure cylinder of tandem compound engines. Fig. 140 shows a horizontal section through the cylinders of a tandem engine. It may be well to call attention to the construction of the pistons and packing gland between the cylinders, which is quite steam tight. Arrows on the drawing explain the action of the valves. A Rites inertia governor of the simpler description controls the valves; it has one inertia bar carrying a new form of eccentric. The novelty of the eccentric consists in having the equivalent of a hinge at one side and an adjusting screw at the other; hence but one screw is needed to take up lost motion.

A bold innovation in the design of crank shafts has combined the much sought wearing qualities of semi-steel and the strength and elasticity of steel. This is secured by casting the semi-steel around a central stiffening core of steel, after which the outer surface is turned and ground before being pressed into the crank discs. A ground tool-steel crank pin is pressed into the crank discs. A patent quick-closing throttle valve with a by-pass for warming up the cylinder, and an indicator reducing motion attachment are among the other features.

Mansfield Engine.

The self-lubricating enclosed simple automatic engine shown in Fig. 142 illustrates one of the several different types of engine manufactured by the Mansfield Engineering Company, Mansfield, Ohio. These engines, which are made in the tandem compound and four-valve types, are equipped with flat slide valves and Rites inertia governors. Other details are not available at the present writing because the engines have only very recently been re-designed.

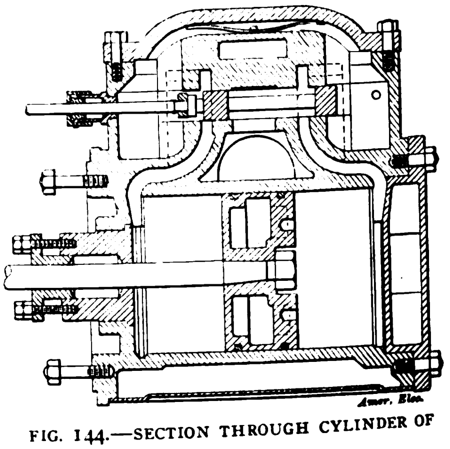


FIG. 144.—SECTION THROUGH CYLINDER OF M'EWEN ENGINE.

Mc Ewen Engine.

A McEwen simple automatic engine, the product of the Ridgway Dynamo & Engine Company, Ridgway, Pa., is shown in Fig. 143, in which the design of the frame, piston, cross-head and connecting rod are plainly illustrated. The section through the cylinder shown by Figs. 144 and 146 clearly indicates the type of valve employed. It is of the flat pattern, being simply a rectangular frame with parallel faces operating between the valve seat and the pressure plate with a steam-tight fit. Recesses in the pressure plate opposite the ports and connecting with them, as shown in Fig. 144, make a full opening to steam and exhaust possible with a minimum valve travel. The pressure plate is held in place by springs, which keep it and the valve against its seat, while all lateral movement is prevented by pins entering its back from the valve chest cover. This valve is also used on the high-pressure cylinder of the tandem compound, and a special form of balanced slide valve is also used.

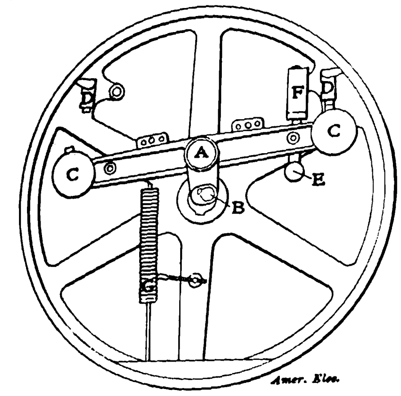


FIG. 145.—M'EWEN GOVERNOR.

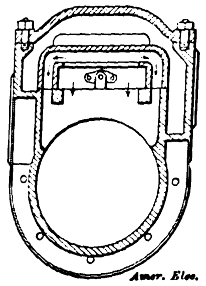


FIG. 146.—SECTION THROUGH M'EWEN CYLINDER.

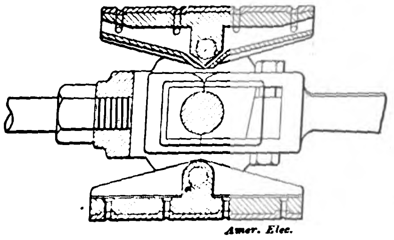


FIG. 148.—M'EWEN CROSS-HEAD.

An inertia governor regulates the speed by changing the travel of the valve and consequently the cut-off. The governor is shown in Fig. 145. It consists of an inertia bar, carrying a small arm on which the eccentric pin is mounted; thus a change in the position of the inertia bar causes a change in the valve travel. To reduce friction to a minimum, the inertia bar is pivoted on a roller bearing fitted with a case-hardened steel bushing.

The cross-head, shown in detail in Fig. 148 is unique in having the babbitt-lined shoes pivoted on eccentric bolts, so that the adjustment of the shoes for wear is reduced to the simple operation of turning the eccentric bolts and then tightening the lock nuts. This swivel mounting also permits the shoes to ride squarely on the guides always. The main bearings deserve note in that they are of a very simple design and are arranged to take up the wear in the right direction. The journal box is shown in Fig. 147.

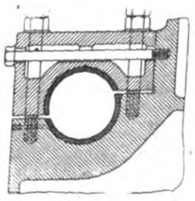


FIG. 147.

Mc Intosh & Seymour High-Speed Engine.

A direct-connected McIntosh & Seymour automatic simple engine is shown in Fig. 149, of which Fig. 150 is a section through the cylinder and valve chest. As will be seen in the latter engraving, the piston type of valve is used with a slight modification of the ends, which gives a large wearing surface. A special feature of interest is the method of keeping the valve steam tight. This is accomplished by means of a split band forming the edges of the port, which can be made to pinch the valve by a screw on the spindle, *S*. By disconnecting the valve rod from the eccentric and moving the valve by hand a delicate adjustment can be made.

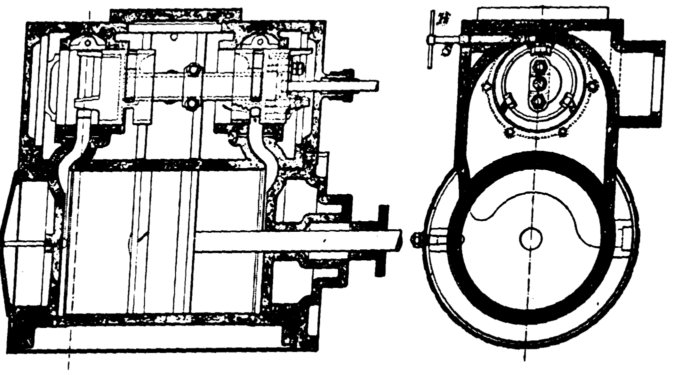


FIG. 150.—DETAILS OF CYLINDER WITH SINGLE PISTON VALVE.

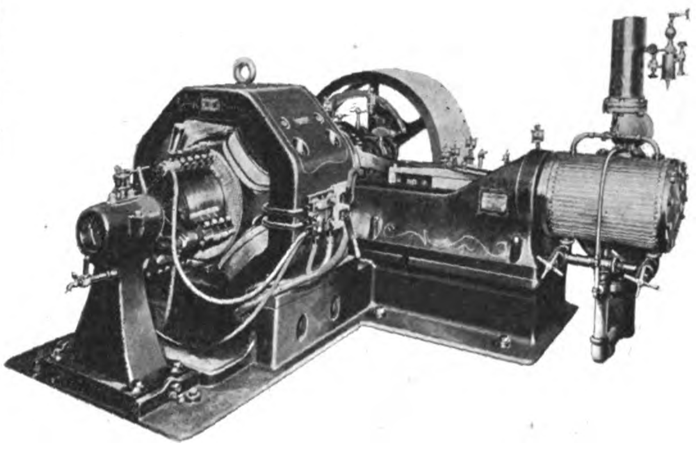


FIG. 149.—M'INTOSH & SEYMOUR HIGH-SPEED ENGINE.

In the compound engines, the piston valve is used, but to obtain a greater range of cut-off a separate cut-off valve is used, which in this case consists of a shell fitting around the main valve, practically riding on it as the cut-off valve does on the back of the ordinary slide valve. The section, Fig. 151, of one of the tandem engines will serve to illustrate this. In Fig. 151 *B* is the steam valve and *A* the cut-off valve, to which the valve stem is attached on the side. The opening to steam is made double-ported on the low-pressure cylinder; the exhaust valves of both, as well as the main steam valve on the high pressure, are made single ported. The operation of the valve can be easily followed on the diagrams by means of the arrows. When cut-off valves are used, the main valves are operated directly from fixed eccentrics, and the cut-off valves are controlled by the governor, which is of the same type as that described previously in connection with Figs. 86 and 87.

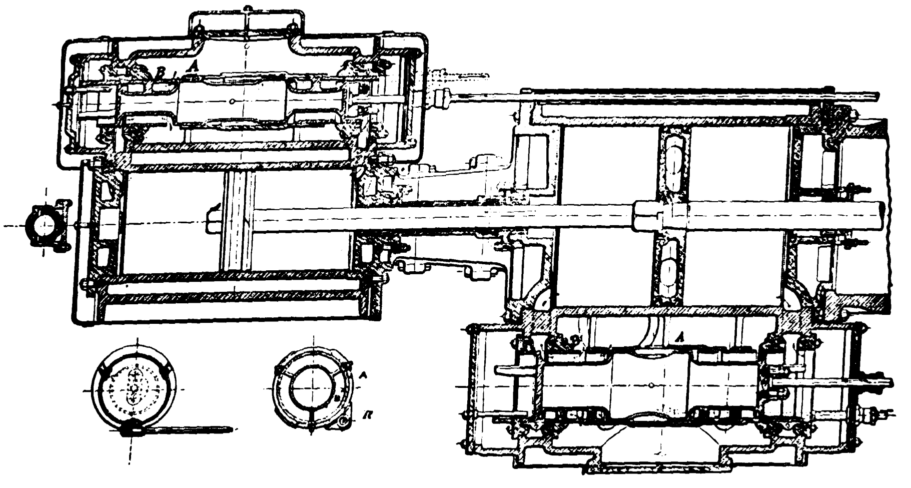


FIG. 151.—DETAILS OF TANDEM-COMPOUND CYLINDERS WITH DOUBLE PISTON VALVES.

A special governor is used on the single-valve engine; this is illustrated in Fig. 152. The governor will be seen to consist essentially of an eccentric mounted on a pendulum, so that it may be moved across the shaft by jaws cut in the governor weights at such an angle that while the weights can easily move the pendulum, the pendulum cannot move the weights. Other details of this engine have the same characteristics as the medium-speed engine of the same makers, previously described.

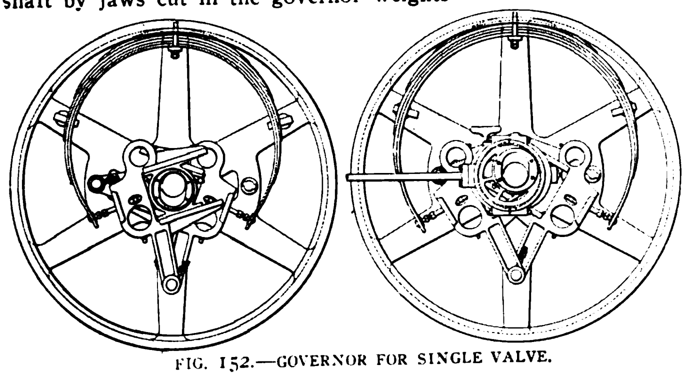


FIG. 152.—GOVERNOR FOR SINGLE VALVE.

New York Safety Engines.

Several styles of horizontal and vertical engines are built by the New York Safety Steam Power Company, New York, of which the engine shown in Fig. 156 is representative. The frames of both the vertical and horizontal engines are of the box type with heavy transverse and longitudinal ribs, giving a rigid support to the bearings and cross-head guides, as will be seen in the sections illustrated in Figs. 154 and 155.

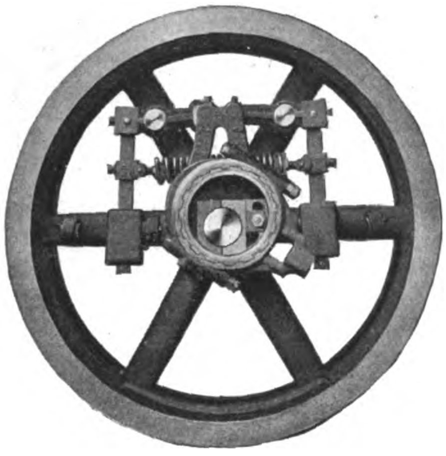


FIG. 153.—GOVERNOR OF NEW YORK SAFETY ENGINE.

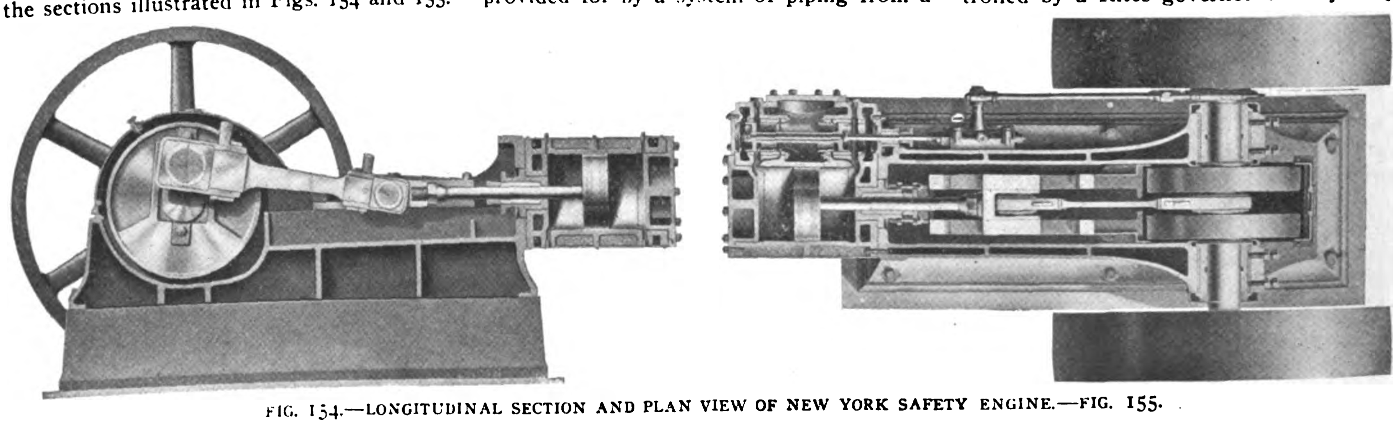


FIG. 154.—LONGITUDINAL SECTION AND PLAN VIEW OF NEW YORK SAFETY ENGINE.—FIG. 155.

Referring to Fig. 155, it will be seen that a simple double-ported piston valve is employed, working in removable bushings, and that the ports are near the ends of the cylinder, giving short straight passages and a small clearance volume. It will also be noted that "peep" holes are provided by means of which the valves can be properly set.

Speed regulation is secured by a shaft governor of the centrifugal type which has two weights, and, as they move outward, force the eccentric across the shaft in ways planed in the fly-wheel, without altering the angular advance. The cross-head is of the locomotive type, made in one piece with the pin, and secured to the piston by a screw and jamb nut. The connecting rod now used is of the marine type at the crank end, but the key-and-cotter construction has been retained for the cross-head end.

Lubrication on the horizontal engines is provided for by a system of piping from a central reservoir situated at a little distance above the bearings and delivering through sight-feed nozzles. A hood over the crank and drip pans under the bearings and the eccentric, catch the excess oil and return it to the crank-pit, whence it is sent back to the reservoir by a small pump actuated by the engine.

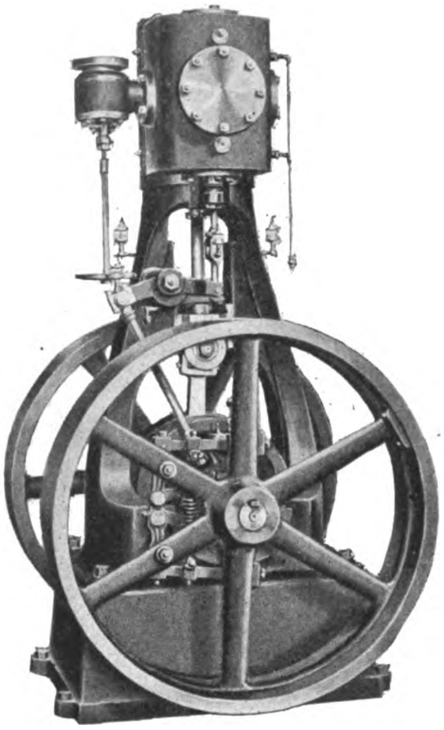


FIG. 156.—NEW YORK SAFETY VERTICAL ENGINE.

Reeves Compound Engine.

The vertical engine shown direct-connected to an electric generator in Fig. 158, illustrates a cross-compound engine built by The Reeves Engine Company, Trenton, N. J. Probably the most prominent features of these engines at first glance are the accessibility of the running parts and the sight feed oil reservoir from which pipe connections lead the oil to all journals needing lubrication. The steam distribution and valves, however, form the most interesting features of the engines. Fig. 159 is a section through the cylinders and valves, which will be observed to be of the piston type operating in liners. The short direct passage from the high to the low-pressure cylinders not only eliminates receiver losses, but is said to cause a slight superheating, by compression, of the steam passing through to the low-pressure cylinder. This feature, with the use of the intermediate valve to control the exhaust of the high-pressure cylinder, thus making the duty of the high pressure valve simply that of cutting off the steam to the high-pressure cylinder, has resulted in the high economy in practice shown by these engines. In Fig. 159 a new cycle of operations is just beginning, the steam being shown entering the high-pressure cylinder at the head end; its further movement can be traced through the engine by the aid of the arrows, remembering that the pistons travel in opposite directions. Regulation in these engines is guaranteed to be within three-fourths of one per cent, this remarkable result being secured by having the intermediate valve driven by a fixed eccentric, which thus gives a compression in the high-pressure cylinder that varies with the load. The high-pressure valve is worked from an eccentric controlled by a Rites governor of very simple construction. The governor embodies a unique feature, in that the suspension pin is turned slightly by a rachet each time the engine starts or stops, preventing uneven wear.

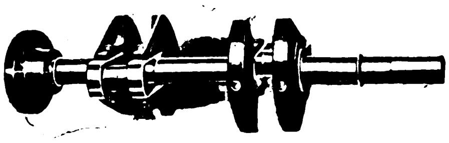


FIG. 157.—REEVES CRANK SHAFT.

The piston valves are readily adjustable at each end independently and without removal from the valve cylinder. This result is obtained by means of the construction shown in Fig. 160. To adjust the lower end of the piston, the nut, *D*, is loosened on the collar, *B*, permitting the rod, *A*, to be turned in the inner thread on the sleeve, *C*, thus moving the conical expander, *F*, and thereby reducing or enlarging the lower ring, after which the nut, *D*, is tightened and the rod, *A*, secured from turning. The expansion of the upper ring is secured in a similar manner by unlocking the threaded sleeve, *C*, by releasing the nut, *E*, thus permitting the sleeve, *C*, to be turned in the thread on, *G*, drawing it up, and in that way increasing the diameter of the ring; it is then locked by again tightening the nut, *E*. While the adjustments are being made it is best to disconnect the eccentric rod, and move the valve by hand in order to make a delicate adjustment. The cross-heads are of the locomotive or marine box pattern, with means for taking up wear, and have the piston rods securely screwed into them and held by a joint nut. Pistons of the hollow design, strongly ribbed, are used. A combination marine connecting rod is employed, having the closed cross-head end and marine-type crank end. Three bolts fasten the counter weights to the solid slotted crank shaft shown in Fig. 157, in which the generous length allowed for the journals is a prominent feature.

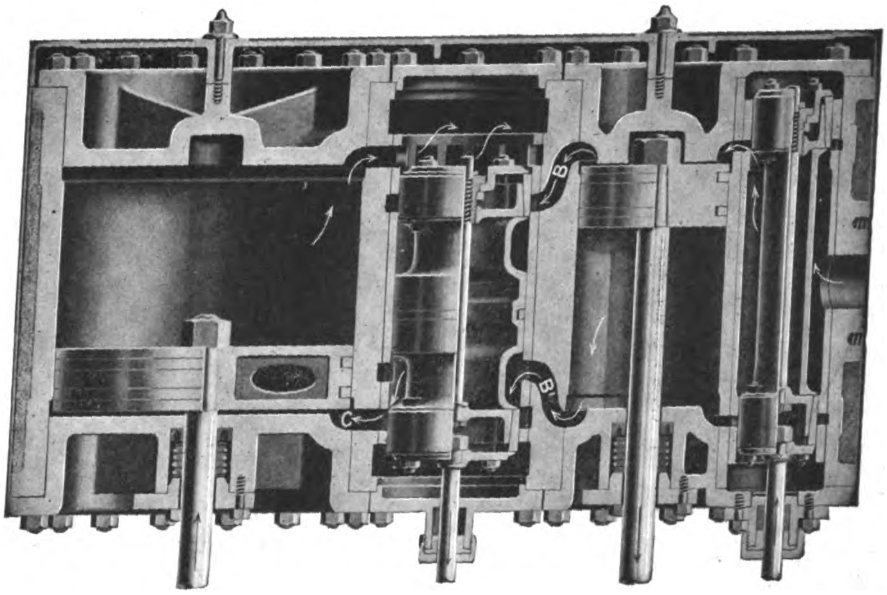


FIG. 159.—SECTION THROUGH CYLINDERS AND VALVES OF REEVES ENGINE.

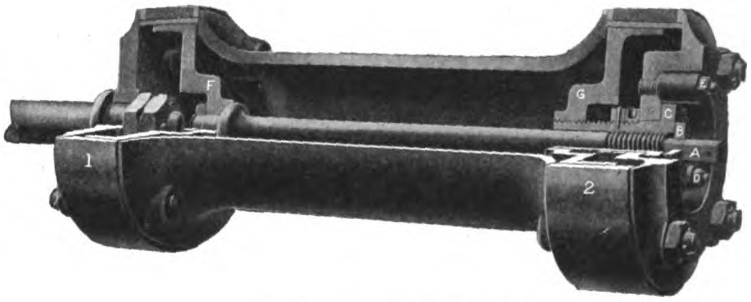


FIG. 160.—REEVES PISTON VALVE.

Skinner Engines.

The Skinner Engine Company Erie, Pa., manufacture a large line of simple and tandem-compound automatic engines, one of which is fully illustrated in Fig. 161, representing the belted type of 200 to 400 horse-power. A very complete separating and filtering system of forced lubrication is employed. First, any water that has been admitted to the oil from the stuffing-box leakage is separated from the oil which is then filtered, after which it is forced to the guides and main bearings by a small pump with positively operated valves.

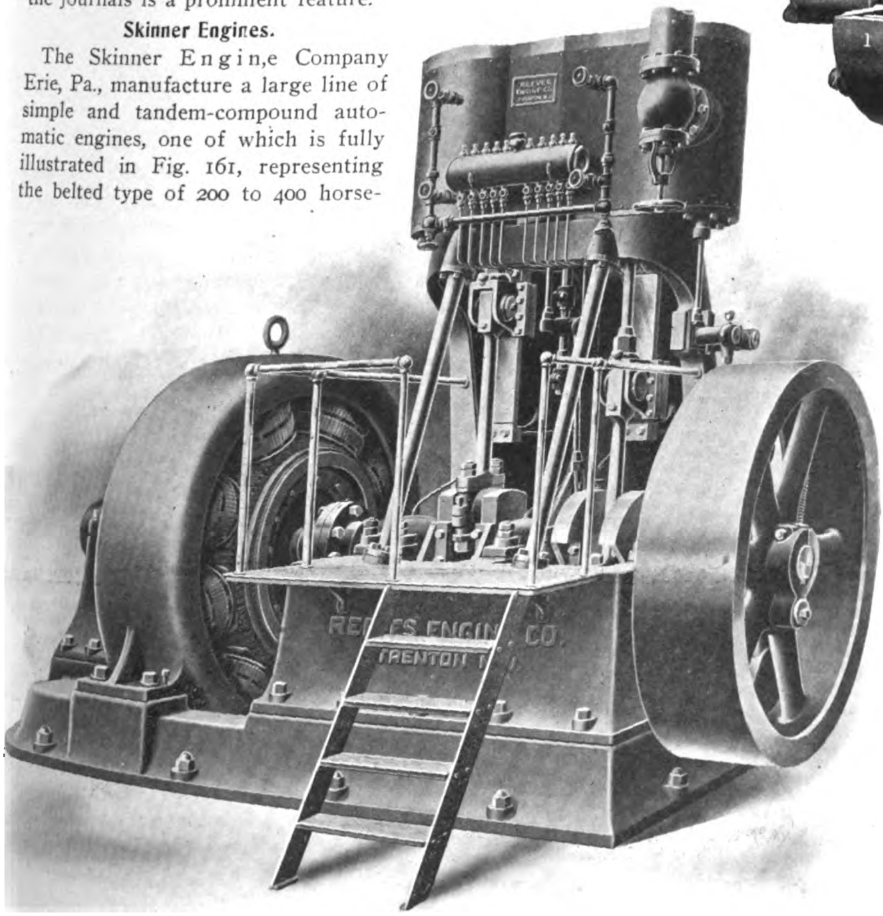


FIG. 158.—REEVES VERTICAL HIGH-SPEED COMPOUND ENGINE.

The valve is a flat slide with 80 per cent of its area balanced by a self-adjusting ring held in contact with the steam chest cover, the inventor claiming it to wear steam tight for an indefinite period of use. These valves, the cylinders, pistons and rocker arm are shown in the sectional plan, Fig. 161, which also shows the type of packing used between the high and low-pressure cylinders. This consists of a sleeve on the high-pressure piston rod, extending into the stuffing box of the low-pressure cylinder; this one packing when lightly screwed up is said to prevent the passage of steam between the cylinders, as well as leakage outside the cylinders. As will be noted, locomotive-type guides and cross-head and separate eccentrics for the high and low-pressure valve are employed. The bed of the engine is made hollow at the crank end, with connecting webs under the main journals, giving rigidity to the construction. The main bearing brasses are adjusted vertically by liners, the lateral adjustment being by means of set screws.

A balanced reversible inertia governor is used, having one inertia bar supported on a roller bearing, the centrifugal force being so opposed by the spring, it is claimed, that the stability of the governor is not affected by the elimination of the friction. (See Fig. 162.)

Shepherd Engines.

The engines built by the Shepherd Engineering Company, Seneca Falls, N. Y., are of the vertical double-acting type, and made in a variety of sizes for all purposes. They are made single cylinder, cross and steeple (or tandem) compound, and the medium and larger sizes are made with both single and multiple valves; they are adapted for both high and medium speeds. Fig. 163 illustrates a cross-compound Shepherd engine driving two 75-kw. dynamos.

The frame and bed are of cast-iron, well ribbed and braced, and contain within themselves the cross-head guides, the valve gear supports, and the seats for the main bearings, thus making it impossible for the working parts to get out of line, except by wear, and adjustment for this is provided. This cross-head guide and the valve-gear brackets are contained in the rear or back frame, and this frame also will support the cylinder when the front frame is removed, thus making it possible to remove the crank shaft from the engine without disturbing the other parts. The crank shaft is made of solid steel, counterbalanced, of course. The main journal bearings consist of adjustable babbitt-lined shells, which can be removed without taking the shaft from the engine. The connecting rod is of steel, the top end being bored out for the cross-head pin boxes, which are made in halves and adjusted by wedge and bolt, while the lower end is slotted for the crank-pin box which is held in place by a mortised and bolted strap adjusted by wedge and bolt. The cross-head is of steel, very light, yet strong and rigid. The shoe is bolted to a yoke on the cross-head, and provision is made for adjustment should the shoe or the slide wear sufficiently to throw the engine out of line. The pin is clamped in place by two bolts. These two clamp bolts pass by the flattened sides of the piston rod, thus preventing it from turning.

The valves are flat balanced slides, adjustable for wear, double-ported for both steam and exhaust, and are free to leave their seats to relieve the cylinders of water.

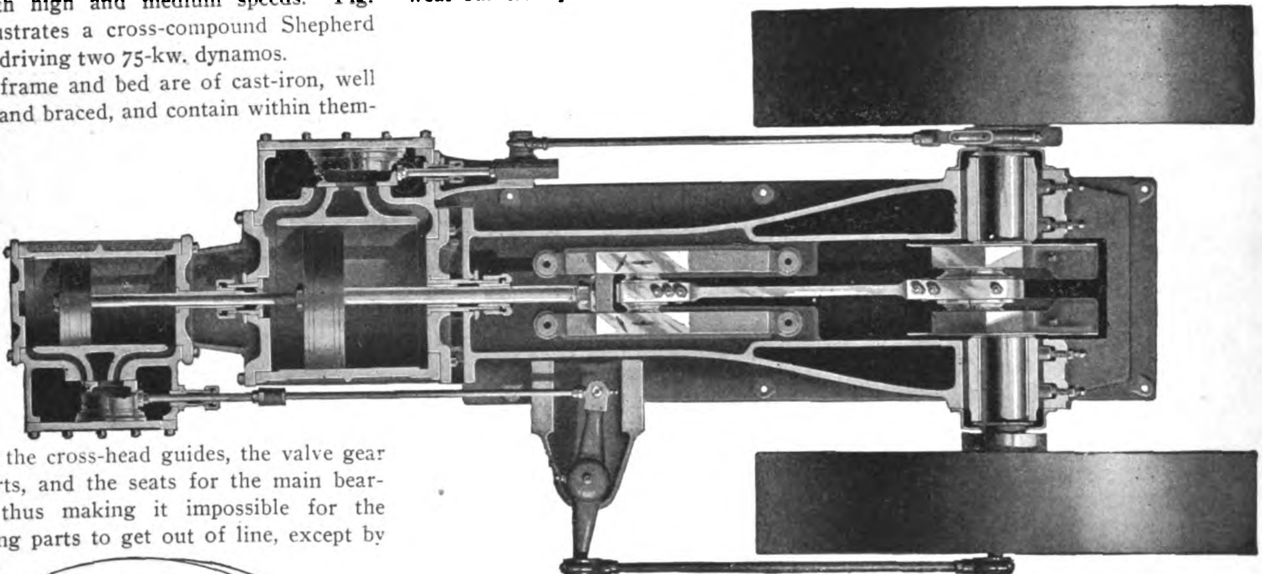


FIG. 161.—PLAN VIEW OF SKINNER TANDEM-COMPOUND ENGINE.

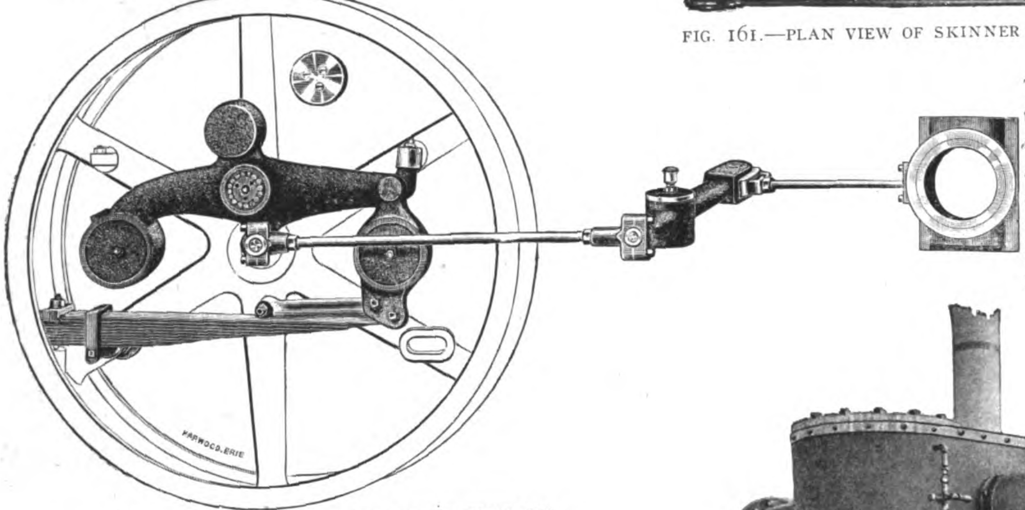


FIG. 162.—SKINNER OUTSIDE CONNECTED GOVERNOR.

The valve gear is of simple, direct and positive construction. The motion of the governor is transmitted to the valve by a rocker arm pivoted to its center, and so constructed that all three of its bearings are in a straight line, thus obviating any twisting stress on any of them. The connection of the valve rod to the rocker arm is by a slotted cross-head and block, which carries the valve rod in a straight line, thereby reducing the wear on the valve rod stuffing box. The slotted cross-head is provided with means of compensating for wear, a

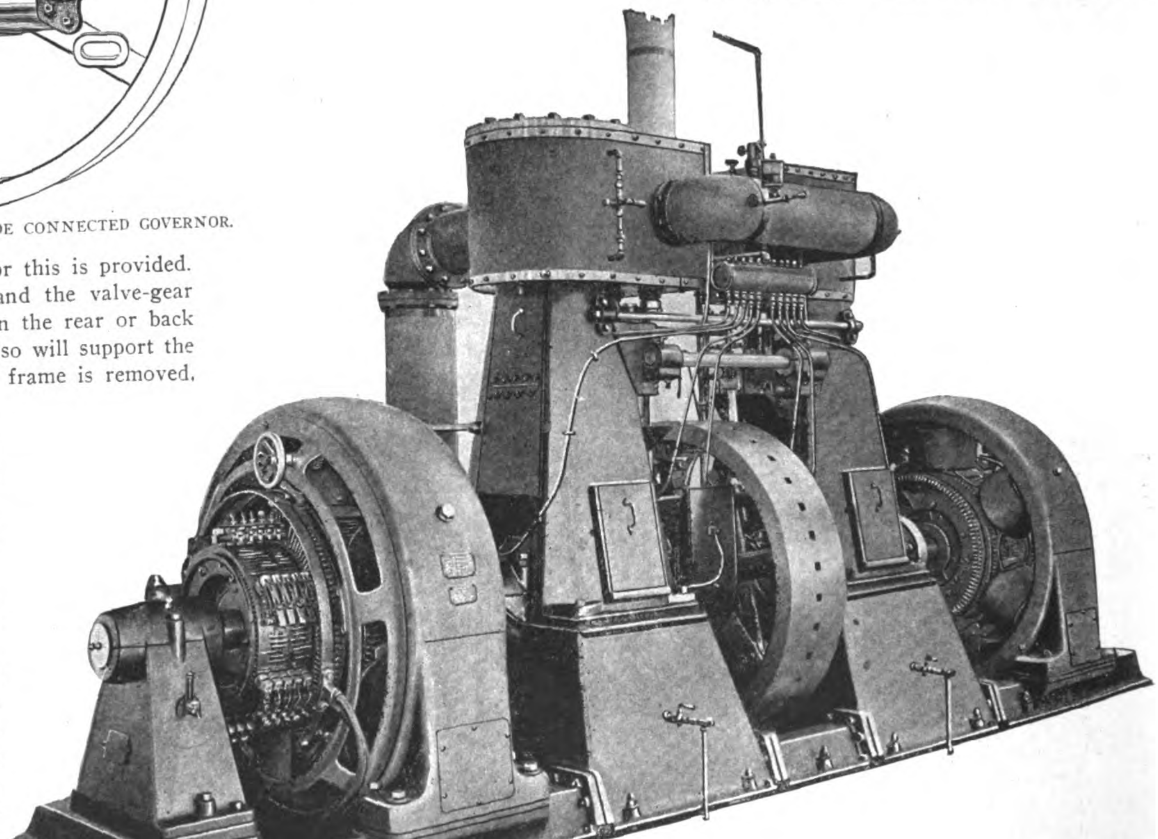


FIG. 163.—SHEPHERD VERTICAL CROSS-COMPOUND ENGINE.

single adjustment taking up the wear on both the block and the rocker-arm pin equally. The eccentric rod has adjustable ball-and-socket bearings at both the rocker-arm and governor ends. The governor is of the well-known shaft type used in one form or another by a number of other engine builders.

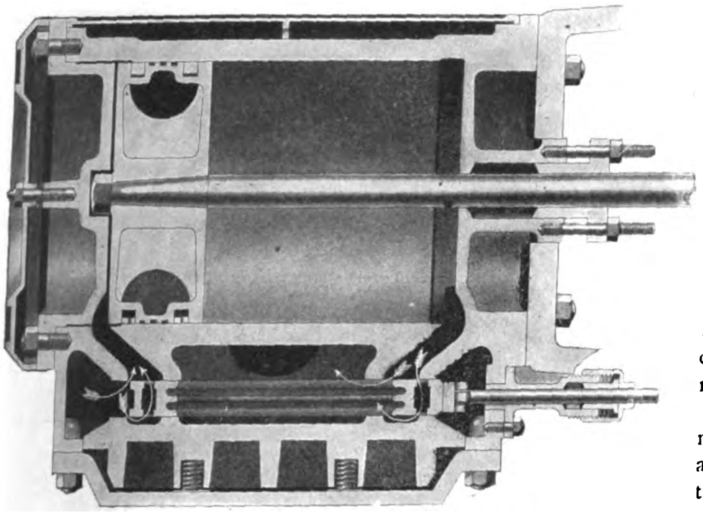


FIG. 164.—SECTION THROUGH WATERTOWN CYLINDER AND VALVE CHEST.

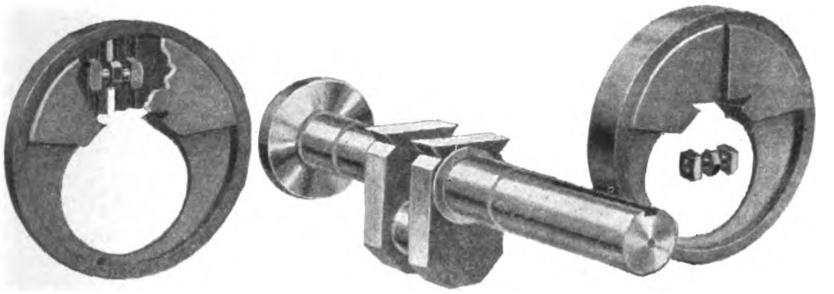


FIG. 165.—WATERTOWN CRANK SHAFT.

Watertown Engine.

The Watertown Engine Company, Watertown, N. Y., builds a line of single and four-valve automatic engines, one of which is shown in Fig. 166. These are also built in vertical and horizontal tandem and cross-compound styles. Fig. 164 shows the construction of the cylinder, piston, valve and valve-seat of the single valve-engine. The valve is a flat balanced slide with the usual pressure plate, which is held against its seat by springs, thus permitting it to relieve any excessive pressure. On the larger cylinders four valves are used, giving a greater range of adjustment and leading to increased economy under light loads, as the point of release and compression are kept constant for all loads. They are flat valves, the steam valve being double-ported and the exhaust single-ported. The method of driving the valves from the valve stems, permitting of separate and independent adjustment of each valve to its seat is clearly shown in the engraving.

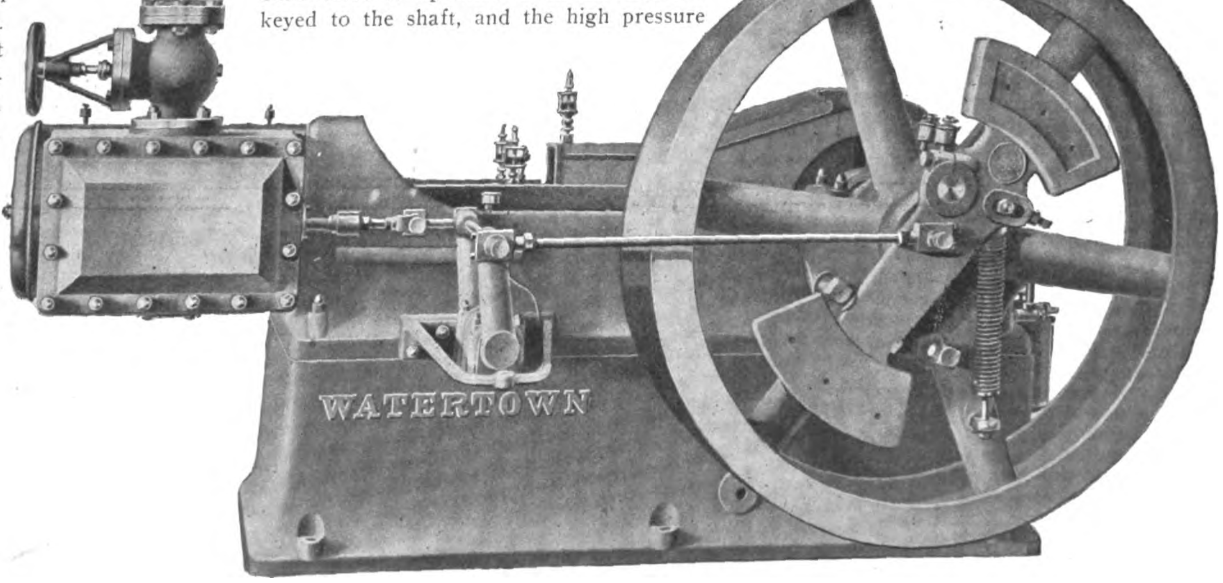


FIG. 166.—WATERTOWN HIGH-SPEED ENGINE.

In Fig. 165 the crank shaft, as well as the simple method of attaching the balance weights to the shaft, is clearly illustrated. This latter feature deserves special mention in that but one screw is needed to clamp the weight and hold it, so that it cannot shift or come off by accident, yet may be easily removed when desired.

Babbitt-lined brasses made in four parts and well supported by the bed of the engine form the main bearings. A forged steel connecting-rod of rectangular cross section is used; the rod has a strap with wedge adjustment at the crank end, and the standard gib and key at the cross-head end. A light locomotive cross-head of great length with ample wearing surface runs in well-lubricated guides, the lower one being formed on the bed itself.

In the compound engines the low-pressure valve is operated from an eccentric keyed to the shaft, and the high pressure valve is worked from an eccentric, which has its throw varied by the governor in the well-known way. The form of governor will be seen from Fig. 166 to be of the simplest Rites type.

Westinghouse Marine Type Engine.

The marine type of engine is a vertical quarter-crank compound, and is essentially a high-speed engine, particularly suitable for direct-connection to generators. Fig. 59 illustrates this type. Its main features comprise a single or sectional bed plate, carrying a sectional built-up shaft and two pairs of split vertical housings or A-frames; each pair being surmounted by one of the two cylinders. The superstructure of the engine is tied together at the top by means of separators between the cylinder castings. In the smaller sizes the bed plate is in a single casting, but in the larger size, it is cast in two sections, united by bolts and sunken flanges. The main bearings are not self-aligning, but are fitted with removable bearing shells with cylindrical seats and wedge adjustment. This adjustment is made from the outside by means of extension bolts passing through the wall of the bed plate. The outboard bearing is self-aligning and mounted upon a sole plate capping the foundation. The housings are of hollow box section, forked at the base and reinforced at the center by transverse braced rods. The rear housings only carry the guides for the cross heads, which are of the single-bearing type. The space in the rear of these bearing plates is cored out, and cooling water may be circulated through them, if necessary.

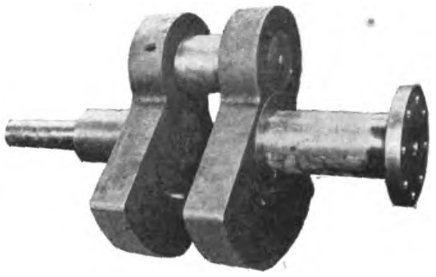


FIG. 167.—WESTINGHOUSE CRANK SHAFT.

Both cylinders are plain-bored without liners, and are provided with re-inforced flanged feet resting upon the top of the housing. The lower head is cast integral with the cylinder, only sufficient opening being left for the admission of the piston rod and packing, but the upper heads are, of course, removable and machined to template in order to reduce clearances.

The shaft is built in two sections, united at the center between the two sets of housings by flanged couplings, this being necessary in order that the crank shaft may be removed without dismantling the engine. The cranks are of the fan tail pattern, assembled at 90° angularity. Fig. 167 illustrates the high-pressure crank of a 2,500-h.p. engine, and shows the arc-shaped slots cut concentric to the shaft in the metal of the counterbalances for eliminating internal strains.

The valve gear of the engine is extremely simple, and is particularly suitable for high-speed engines of this class. On the high-pressure cylinders a balanced double-ported piston valve is used, and on the low-pressure a semi-balanced, single-ported rectangular slide valve. In special cases, where desired, the slide valve on the low-pressure cylinder is displaced by two piston valves of the same general design as those on the high-pressure side. This alters somewhat the steam distribution on the low-pressure side of the engine, as noted below. The two halves of each piston valve is mounted on an adjustable sleeve independent of the valve rod, and the entire weight of the valve is counteracted by the small balancing piston in the valve chest cover. The steam chest is provided with cast-iron liners which may be removed when necessary. The slide valve has two valve rods and seats under moderate pressure, due to the small area exposed to the steam, but the main portion of the valve is relieved from pressure by a cover plate cast integral with the steam chest cover. Small equalizing ports are also furnished in the low-pressure valve to prevent flapping at low pressures.

The cylinder ratio adopted in engines of this type is about 1 to 4 for condensing and 1 to 2½ for non-condensing. The cut-off at the low pressure cylinder is constant, the valve being driven from a fixed eccentric; the high-pressure valve is operated from an eccentric controlled by an inertia governor, mounted in a heavy governor wheel which considerably augments the fly-wheel effect of the rotating element of the generator.

Westinghouse High-Speed Engines.

The smaller Westinghouse high-speed engines are all of the single-acting type. This line comprises the Junior, built in sizes of 5 to 50 horse-power; the Standard, 5 to 300 horse-power, and the Compound, in sizes of 50 to 400 horse-power.

The Junior, Standard and Compound engines each have many features in common, such as: enclosed crank case, containing a mixture of oil and water, into which the cranks dip, thus providing automatic lubrication; plain vertical cylinders mounted upon the crank case; trunk pistons double-walled at the top to reduce the transfer of heat; balanced piston valves; outer bearings with removable shells attached to the crank case; downward thrusts only, reciprocating stresses in the moving parts being avoided, and inherent self-contained construction.

The distinguishing features of the Standard engine are the internal governor and peculiar location of the steam chest. The former is mounted upon a disc secured to one of the cranks. The governor is of the centrifugal type, operating the valve through an eccentric. The shaft is forged in one solid piece with cranks slotted out by machine. The centers of the cylinders do not lie oiver the center of the shaft, but to one side of it, at a distance equal to one-half the crank length. This is permissible because of the employment of the single-acting principle and decreases the effect of the angularity of the connecting-rod by one-half. This feature is shown in Fig. 170, and the general construction of the engine is illustrated by that engraving. The valve chest is set at an angle to the vertical plane in order to shorten the distance between the cylinders, as shown and the valve is balanced by the cross-head piston and balancing piston beneath. In the larger sizes the main bearing shell is split horizontally, and a wedge adjustment of bearing shells provided when the engine is to be direct-connected to generators.

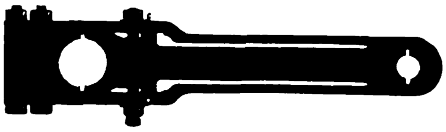


FIG. 169.—CONNECTING ROD.

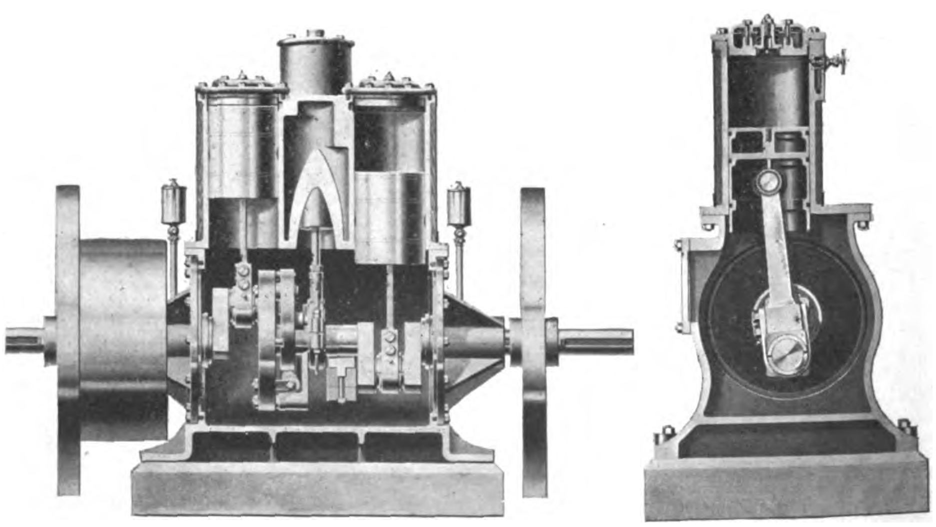


FIG. 170.—WESTINGHOUSE STANDARD ENGINE.

A considerable amount of expensive machine work in the Standard engine has been avoided in the Junior by placing the valve chest on the top of the cylinders, and the governor in a wheel mounted on the end of the shaft, in the usual manner. The distance between the cylinders is thereby shortened, and the middle bearing within the crank case may be dispensed with. The valve is similar to that of the Standard, and the governor is of the inertia type controlling the valve movement through a 90° bell-crank lever. The same steam economy is obtained as with the Standard.

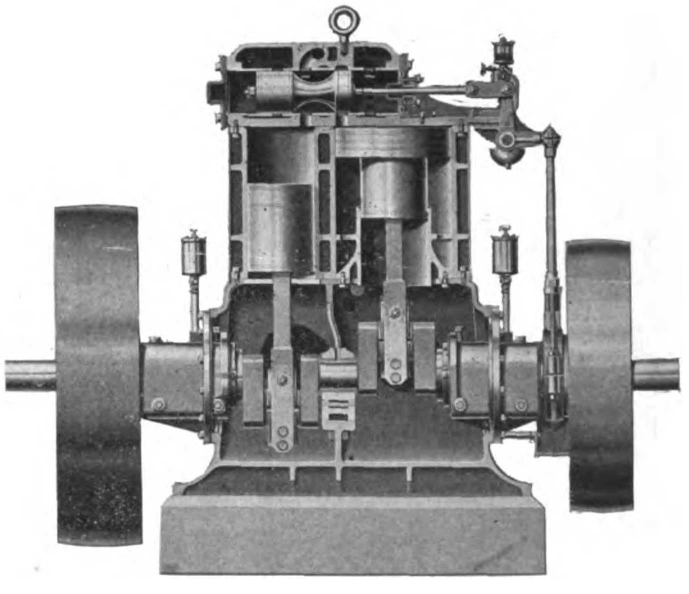


FIG. 168.—WESTINGHOUSE COMPOUND ENGINE.

The construction of the single-acting compound differs from that of the Standard chiefly in the steam distribution and the cylinder ratio—one cylinder takes steam at boiler pressure and exhausts to the other one, exactly as in the case of a two-cylinder, double-acting compound engine. There is also a difference in the valve arrangement. The valve gear is operated through a 90° lever and eccentric by an automatic governor of the inertia type. The valve is a simple piston valve, spring-packed, and works within a renewable valve liner containing the necessary port openings to the valve chest and cylinder head. The latter form a single and distinct part of the engine. The steam distribution in this engine is such that with cranks placed at 90°, the expansion of steam, partially carried out in the high-pressure cylinder, is completed in the low-pressure cylinder without the use of receiver capacity other than that furnished by the space surrounding the valve. The division of load between high and low pressure cylinders is moreover maintained approximately uniform throughout reasonable changes of load, so that the economy curve is quite flat for all loads above 50 per cent and does not begin to rise abruptly until the load is reduced to 25 per cent of full rating. The steam and exhaust passages in the valve chest are separated by a partition, and the valve arrangement is such that contiguous parts are never subjected alternately to the initial and final temperatures. Another distinctive feature of the engine is the peculiar form of connecting rod used (see Fig. 169). As the thrust is always downward, adjustments at the top of the rods are dispensed with. The central bar of the rod transmits the entire thrust of the piston, and the narrow steel strap, *A*, which passes entirely around the bar, serves merely as a retainer for the outer halves of the box shells. The compound engine has three bearings, the central one being located in the inside of the housing, and the two outside bearings being bolted to the ends of the crank case. All three bearings are fitted with split bearing shells, and may be adjusted by means of wedges for taking up the wear.

Willans Ultra High-Speed Engines.

The Willans engine is now manufactured in this country by the Bradley Manufacturing Company, Pittsburg, Pa., who have secured the American rights. The most peculiar point in the design of the Willans engine is in the valve mechanism. The valve is of the piston type and operates within the piston rod, which is therefore hollow and relatively large. In order to have the valve move in its proper relation to the ports, it is necessary to give it motion relative to the piston rod, which is accomplished by placing the eccentric on the crank pin, the eccentric rod working between two exactly similar connecting rods which operate on the crank-pin on either side of the eccentric. In the larger sizes, from one to six of these units are placed side by side, all working on a common shaft with the cranks set at equal angles apart, thus giving a very even turning movement such as is required for the parallel operating of alternators. The crank shafts are all made out of a solid forging, having the eccentrics turned on the pins.

These are essentially very high-speed engines, and to secure this result without the danger of knocking, the rods are maintained continuously in compression. Two methods are used to secure this end: First, the cylinders are made single-acting, and secondly, an air cushion chamber is provided, which also serves in the place of the usual cross-head and guides, and has therefore been termed the guide piston. The eccentric rod is kept constantly in compression by the pressure of the steam on its top, though when running very lightly loaded the pressure may be so reduced by throttling as to produce a slight knocking.

A section through a two-crank simple engine is illustrated in Fig. 171, which shows one of the pistons in section and the other in elevation. The steam is shown entering the left-hand cylinder through the ports 7, 7 and 8, 8 cut in the trunk. Admission continues until the ports, 7, 7, enter the gland, C^3, which thus determines the cut-off, which may be varied at will by raising the gland by hand, or the engine may be so arranged that the gland is raised automatically by the governor. On the up-stroke, the valve, V^3, will be above the ports, 8, 8, thus permitting the steam to pass into the exhaust chamber through the ports, 8, 8 and 9, 9, which are in communication through the trunk. The operation of the Willans compound engine is exactly the same as that of the simple engine, excepting that, as is evident, since the steam is working during only one-half of one revolution between the succeeding stages, it must be stored in a receiver for that period. This is one of the chief advantages of this engine, as it provides a means of dividing the temperature range more advantageously in the different stages.

In conclusion, the writer wishes to express his appreciation of the assistance rendered by the engine builders whose products are described herein, and his regret that lack or tardiness of co-operation on the part of several other manufacturers prevented their engines from being included in this article.

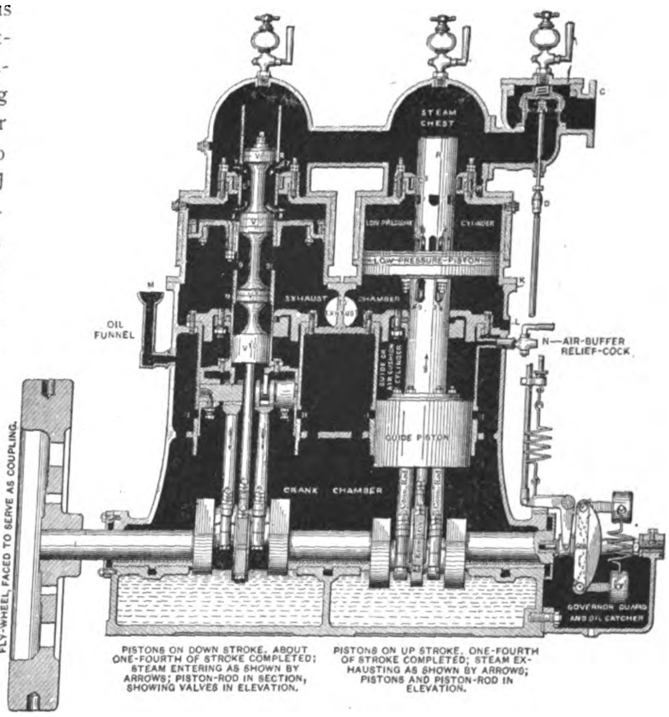
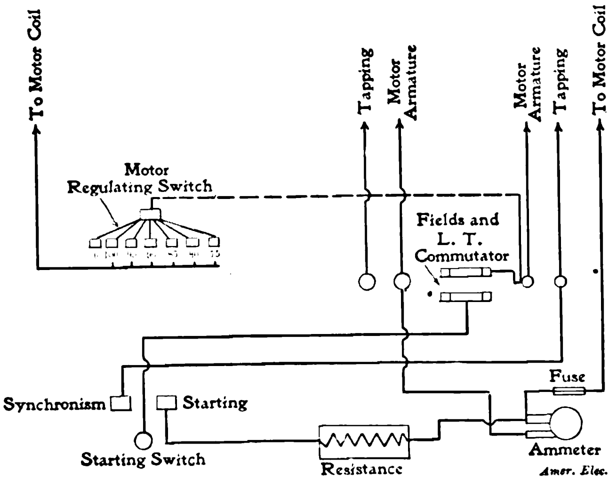

STEAM CHEST
LOW PRESSURE CYLINDER
LOW-PRESSURE PISTON
EXHAUST CHAMBER
EXHAUST
GUIDE OR AIR CUSHION CYLINDER
GUIDE PISTON
CRANK CHAMBER
OIL FUNNEL
M
C
D
K
L
N—AIR-BUFFER RELIEF-COCK
GOVERNOR GUARD AND OIL CATCHER
FLY-WHEEL FACED TO SERVE AS COUPLING.
PISTONS ON DOWN STROKE, ABOUT ONE-FOURTH OF STROKE COMPLETED; STEAM ENTERING AS SHOWN BY ARROWS; PISTON-ROD IN SECTION, SHOWING VALVES IN ELEVATION.
PISTONS ON UP STROKE, ONE-FOURTH OF STROKE COMPLETED; STEAM EXHAUSTING AS SHOWN BY ARROWS; PISTONS AND PISTON-ROD IN ELEVATION.

FIG. 171.—WILLANS SIMPLE CENTRAL VALVE ENGINE.

Abstracts from Foreign Contemporaries

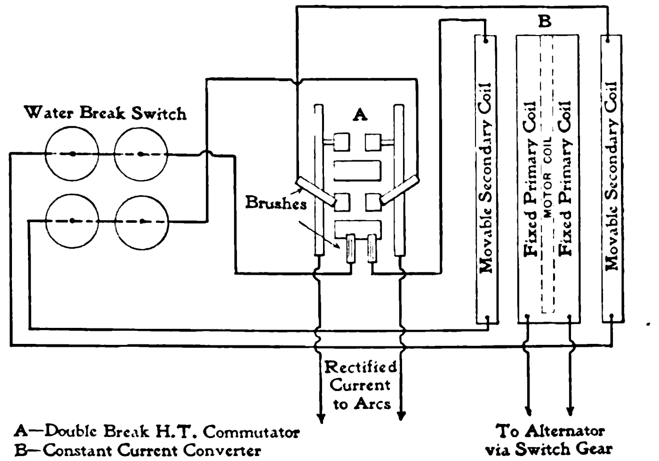
Dangerous Rise in Voltage Due to Resonance.—Felix Finckh gives, in a recent issue of the *Elektrotechnische Zeitschrift*, an instructive account of a somewhat unusual rise in voltage which occurred on a 1000-kw. 2000-volt three-phase alternator at St. Petersburg. The machine had worked satisfactorily for a number of years, both in parallel with others and alone, but after a time it began to give trouble by breaking down repeatedly between one particular coil and the iron through a 4-mm. mica tube. The breakdown was always accompanied by violent crackling sparks at the outer edges of the coil, indicating the presence of extremely high voltages. Investigation showed that at the time when the trouble commenced a variable earth occured on the high-tension network. Further, it had been noticed that violent shocks could be obtained by touching the stationary armature iron of this particular alternator, whilst no such shocks could be obtained from the other machines. The earth fault would disturb the symmetry of the different terminal potentials to earth, and would tend to pass a charging current from the armature iron to earth. The shocks obtainable from the armature iron indicated that an insulting layer existed between the latter and the earthed frame. This insulation had probably been formed in the course of time, owing to the accumulation of dirt, as no special arrangements for insulating the iron from the frame were visible. On this particular machine, therefore, the charging current induced by the earth fault could not, as in the other machines, flow direct to the earth, but had to pass through this thin layer of insulation between the iron core and the frame, probably with the accompaniment of sparking. The engineer felt that this sparking, by giving rise to high-frequency currents of short wavelength, was probably the cause of the excessive voltage rise in the armature, as harmful resonance effects are in practice probably much more commonly caused by such currents than by the main current. If this were the correct explanation, the trouble would cease if the iron core were metallically connected to the earthed frame. As the fault in the high-tension net-work had in the meantime been made good, and as it was not considered advisable to reintroduce it for the purposes of experiment, it was necessary to make other arrangements for investigating the point. The necessary conditions can be obtained by simply connecting one terminal of the machine to the bus-bar. The machine may be at rest and unexcited, and the charging current between the core and earth will then be due to the phase voltage—$2000 \div \sqrt{3}$ volts. This method was employed, and as soon as the connection to the bus-bar was made, the effects described were repeated, crackling sparks as much as 40 mm. in length jumping over to the iron. These sparks disappeared as soon as metallic connection was made between the core iron and the frame, and they reappeared on breaking this connection again. The connection between core and frame was then made permanent, and since then the machine has given no trouble whatever. No reason was discovered for the occurrence of the sparking always at one particular coil.

Series Running of Arc Lamps by Rectified Currents.—W. Rogers contributes to the London *Electrical Engineer* some notes on the series running of arc lamps by rectified currents, in which he discusses the advantages of rectified currents over alternating currents for running arc lamps. The luminous efficiency of the direct-current arc is greater than that of an arc with an alternating current, since in the latter case no crater is formed, and about half of the light is thrown upward and therefore lost. When high-tension alternating currents are used for distributing power for arc lamps, to secure the high efficiency arc it becomes necessary to employ either a motor-generator set or a rectifier. An installation using rectifiers was made in Portsmouth eight years ago, and has been working satisfactorily since that time. A rectified current, it might be added, is not a continuous current, but consists of a series of currents flowing in one direction, at the same time rising and falling in the same manner as an alternating current, 40 to 100 times per second. The rectifying apparatus consists of three parts: a constant-current transformer, a synchronous motor, and a high-tension commutator driven at synchronous speed by the motor.



Amer. Elec.

FIG. 1.—MOTOR CONNECTIONS.



Amer. Elec.

FIG. 2.—CONSTANT-CURRENT CONVERTER AND COMMUTATOR CONNECTIONS.

Considering first the transforming part of the apparatus, the current is brought through oil-break plug fuses to fixed primary coils. The secondary coils are movable, and are fixed on a gunmetal carrier, sliding on ball bearings. They are also geared together by quadrants and racks. These secondary coils are free to move outward from the primary coils when the magnetic repulsion is sufficient to lift an adjustable counterpoise. A water-break switch enables the load on the bus bars to be put on gradually, consequently minimizing the effects of inductance. The connections of the synchronous motor are shown in Fig. 1. In the earlier types of rectifiers the motor was made self-starting by splitting the single-phase current into two currents of different phases. The method used is that due to Brown, Boveri & Co., and consists in passing half of the current through a non-inductive coil, and allowing the other half of the current to pass through a coil which has induction. This latter current is then a quarter period behind the current in the non-inductive coil. Hence two currents are obtained differing in phase from each other. In the latest type of apparatus the motor is made self-starting in a different manner to that mentioned above. The driving current for the motor is obtained from a small secondary coil fixed between the primary coils of the constant-current transformer. The motor has four stationary armature coils wound with adjacent coils of opposite polarity, the revolving field being fed with a rectified current to ensure the poles being kept at constant polarity. The field only requires a few volts when the motor is in step, this pressure being obtained by taking tappings from a coil of the armature. In running up to synchronous speed the fields are first put in parallel with the armature through a resistance, and by means of a starting switch they are changed over to the low-voltage tapping when synchronism is obtained. The speed of the motor is about 1,500 revolutions per minute, with an output of one-half horse-power. It varies slightly with special periodicities. The high-tension commutator consists of three spider-shaped castings, with hard-drawn copper segments riveted to them to take wear on the brushes. With the commutator running at synchronous speed, the circuit is broken in two places on each pole near the zero line of the alternate-current curve. Each pulsation below the zero line is reversed, changing the ordinary alternate-current curve to a rectified-current curve, this latter curve representing the unidirectional current, which is distributed to the lamp circuit. Comparing the cost of rectifiers with other systems, it is said that the initial outlay in station plant required for a rectifying system is only one-quarter of that for a direct-driven, continuous-current set of the same output, while the floor space is about half. As regards consumption of carbons, it has been found that the cost of carbons used on a rectified circuit was just half as much per annum as on a alternating-current system. Tests of these machines have show an efficiency of 91 per cent, with a power-factor of 0.9.

The Action of Electrical Shock.—The precise nature of the effects which cause death from electric shock are still obscure and the subject of discussion. According to a report, however, which has been made by Dr. F. Battelli, of the University of Geneva, and which is abstracted in the London *Mechanical Engineer*, it would seem that currents of high tension cause death in a different manner to currents of low tension. The former, say currents of 1,200 volts and more, kill by inhibition of the nerve centers and arrest of the respiration. The heart continues to beat with energy, and is only arrested by asphyxia, causing great arterial pressure and muscular tetanus of the whole body. In such cases the animal can in general be restored by artificial respiration. On the other hand, currents of low tension, *i.e.*, not exceeding 120 volts, passing from the head to the feet, kill by producing paralysis of the heart, the nerve centers being little affected, and the animal "continuing to breathe for some time after death." These low-tension currents, apparently, stop the heart action by causing irregular contractions, and thus destroying its rhythm. Dr. Battelli and Professor Prevost have made the remarkable discovery that high-tension currents are even capable of restoring the action of a heart that has been arrested by a low-tension current. As the application must, however, to be successful, be made not more than 15 to 20 seconds after the arrest of the heart's action, it is hardly likely to prove much of a practical restorative. The path traversed by the current in passing through the body is a matter of great importance as regards effects. The most dangerous is from one hand to the other, because the resistance of this path is low, and also because the current passes near the heart. Hence it is a good rule for workmen and others handling live conductors to use one hand only. An important rule to observe in rescuing a person in contact with a live conductor, if it is impossible to switch off the current and no insulating appliance is available, is to push the victim off with the foot. Even if the current should pass from one foot to the other through the rescuer, the resistance through the boots and the limbs is considerable, and, as the current does not pass near the heart, serious injury is not likely to result.

New Water Gauge.—The London *Engineer* contains an illustrated description of a new water gauge shown by Fig. 4 herewith, which has two or three features of interest, one of which is the device by which the gland nuts are done away with. The ordinary kind of glass tube is used, but instead of putting it into the frame in the usual way and making the joints at its ends tight by means of stuffing boxes, the tube is mounted in a brass cartridge of the form shown in the engraving. In this the tube is made steam-tight by means of a rubber washer and screwed nipple. This cartridge, complete, is wholly independent of the frame, and in the event of a glass breaking a new cartridge is dropped into place, and by the mere action of screwing down the upper cap steam-tight joints are made at both ends without the trouble and danger of packing joints. The idea is excellent so far, and the only weak point in it seems to be the use of four rubber washers. Whether these will last is questionable. The makers recognize that under some conditions the washers outside the cartridge case may deteriorate, and in such cases they recommend, when length permits, the use of glands top and bottom, the cartridge being retained, but slightly modified, to suit the circumstances. Even under such conditions much may be said in favor of the main idea. The "cartridge case" is open in front, and at its back inside has a "refraction dial" for indicating the water level clearly. In the absence of glands the length of glass is, of course, greater than would be the case with an ordinary frame of the same centers. The construction of the automatic valve at the bottom is obvious. The top valve does not completely close in the case of a broken glass, the small hole through it allowing a little steam to escape. It is claimed that this is insufficient to be dangerous and serves to attract attention to the gauge when the glass is broken.

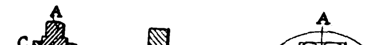


FIG. 4.—WATER GAUGE.

Sal Ammoniac Tests.—M. G. Rosset, in a recent number of the *Centralblatt fur Accumulatoren and Elementenkunde*, gives details of two useful physical tests for determining the purity of ammonium chloride (sal ammoniac) intended for battery use. These tests can be carried out by anyone with comparatively simple apparatus, and they enable 5 per cent of sodium chloride (the most usual adulteration of the ammonium salt) to be detected with ease. The two tests are based on the change in the coefficient of heat absorption, and in the specific gravity, when sodium chloride (common salt) is present as an impurity. The change in the coefficient of heat absorption is most marked with dilute solutions, and when 25 grains of the salt are used in 250 cc. of water, the temperature and coefficient variations are as follows:

	Fall in temperature.	Coefficient of absorption.
Pure ammonium chloride	6.0° C.	.24
NH_4 Cl with 5% Na. Cl.....	5.75° C.	.23
NH_4 Cl with 10% Na Cl	5.50° C.	.22
NH_4 Cl with 15% Na Cl	5.25° C.	.21
NH_4 Cl with 20% Na Cl	5.00° C.	.20
NH_4 Cl with 25% Na Cl	4.75° C.	.19
Pure sodium chloride	1.50° C.	.06

The coefficient of absorption being equal to the fall of temperature divided by the weight of the dissolved salt.

As regards the check test, the specific gravity of a saturated solution of pure ammonium chloride at 15° C. is 1.0766, and should such a solution show a higher specific gravity at the temperature named, this signifies the presence of sodium cholride, or some other impurity. The following figures show the variations in specific gravity caused by increasing percentages of sodium chloride, when using a solution containing 25 grains of the ammonium chloride in 250 cc. of water:

Ammonium chloride, pure	4.33 Baumé
Ammonium chloride with 10% Na Cl	5.00 Baumé
Ammonium chloride with 20% Na Cl	5.50 Baumé
Sodium chloride, pure	9.00 Baumé

For carrying out the temperature-depression test, it is advisable to use a thick glass flask of about 1 litre capacity, and after vigorously shaking the weighed quantity of salt with 250 cc. of water, to quickly read the temperature of the immersed thermometer. As the depression occurs in from one-half to three-fourth minute, no time must be lost in noting it, and it is further necessary to start the test with both the salt and water at the *same temperature*—preferably that of the room.

Foster's Stop Valves.—The accompanying engravings illustrate a series of stop valves which are described in the London *Engineer*. Fig. 5 shows a non-return automatic emergency and hand stop valve. It is intended for use with batteries of boilers, and to cut off an injured boiler instantly from the rest, so avoiding the outrush of steam from the sound boilers. Fig. 6 shows the auxiliary valve by which Fig. 5 is brought into action. Fig. 5 shows an angle valve, but straightway or globe pattern bodies are furnished as required. The proportions shown are of a 10-in. valve, for pressures as high as 250 pounds, but the valves are made of ample strength to withstand any required high steam pressure. The operation is as follows: As a non-return valve: The moment flow of steam in the main ceases—as by the stopping of the engines—valve 2 instantly closes against its seat, regardless of pressure in the boiler or steam main. A dash-pot is provided, as shown, to prevent chattering or hammering.

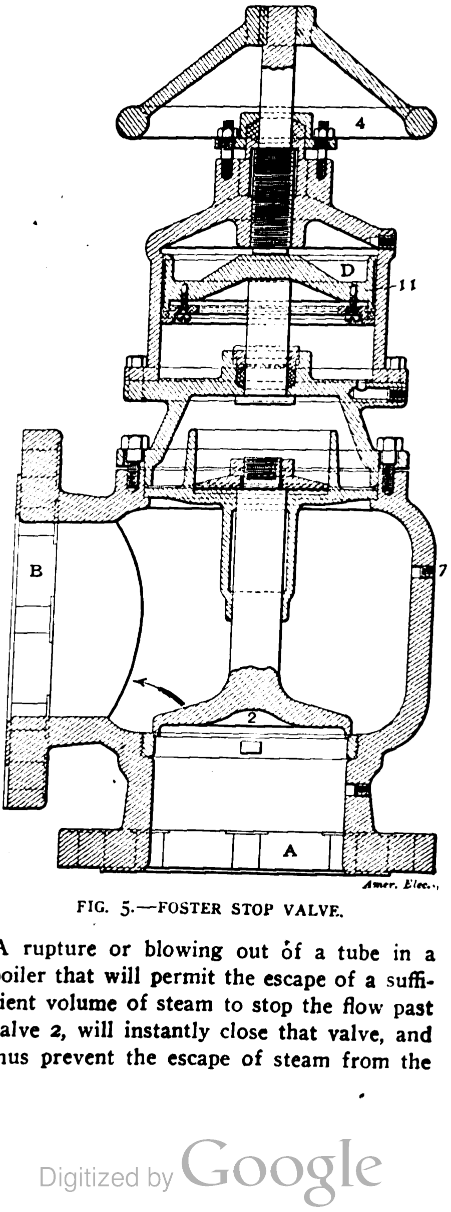


FIG. 5.—FOSTER STOP VALVE.

A rupture or blowing out of a tube in a boiler that will permit the escape of a sufficient volume of steam to stop the flow past valve 2, will instantly close that valve, and thus prevent the escape of steam from the other boilers back through the disabled ones. As an automatic and emergency stop valve, the small auxiliary valve, 5 (see Fig. 6) which may be placed in juxtaposition to the main valve, or fixed at some distance or more accessible point, is connected by suitable small pipes to the boiler and to the chamber, *D*, of the large valve. It also has a pipe connection from the diaphragm chamber, 6, to the outlet side of the main valve casing, as at 7, or to some more distant point on the main pipe-line. Spring 8 of this auxiliary valve is adjusted to resist any predetermined pressure, say 100 pounds, on the diaphragm in the chamber, 6. Whenever, from rupture or other cause, the pressure in the main pipe-line falls to or below 100 pounds, the spring, 8, will simultaneously close valve 9 and open valve 10, allowing full pressure to flow from the boiler through the auxiliary valve into chamber *D* against piston 11, which, being of greater area than valve 2, instantly closes the latter against its seat and prevents the flow of steam in either direction. Valve 2 having been closed, automatically or manually, and the pressure in the main having fallen below 100 pounds, valve 2 will remain closed indefinitely until a pressure above 100 pounds from some connecting boiler is again admitted to the main, or when, by means of the small hand-wheel, 12, valve 10 is closed, and simultaneously valve 9 is forced open. The steam from the chamber, *D*, will now flow back through the auxiliary valve and escape to the atmosphere through a drain pipe connected on the lower side at 13. Now, if the steam in the boiler is of greater pressure than in the main and its connecting boilers, the valve 2 will be forced open to permit the required flow into the main.

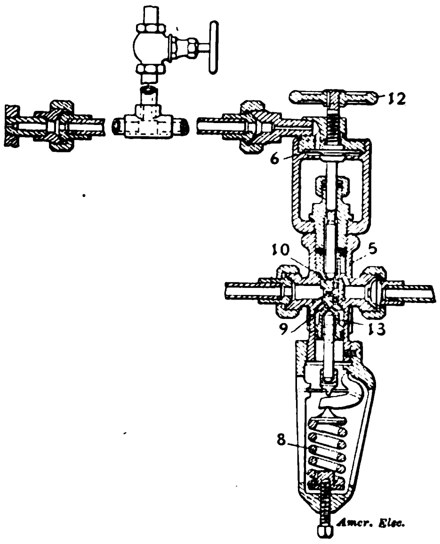


FIG. 6.—AUXILIARY VALVE.

A number of small pipes may be branched from the one leading to the diaphragm chamber, 6, of the auxiliary valve, and led to distant points of the building. On each of these branch pipes, at an accessible point, is placed a three-way cock. The main valve may be instantly closed from any of these distant points, by turning the three-way cock so as to bleed the pressure from the diaphragm chamber of the auxiliary valve into a waste-pipe, the inlet pressure at the diaphragm chamber being supplied through a restricted opening in the pipe, as at *c* in auxiliary valve. By the use of hand-wheel 4 (see Fig. 5) valve 2 may be closed manually against the flow of steam in either direction, as easily and effectively as in the ordinary hand stop valves.

SOME RECENT ELECTRICAL PATENTS

High-Voltage Incandescent Lamp.—As is well known, there is considerable difficulty in producing an incandescent lamp of fairly high efficiency for operation on relatively high voltage circuits, such as 220 volts and upward. The chief reason is that a filament sufficiently long and thin to give the desired economy is extremely difficult to handle successfully during the treating and exhausting operations in the course of manufacture. Mr. John W. Howell, of the General Electric Company, proposes to eliminate this difficulty by the use of two or more filaments individually prepared and connected in series when mounted in the lamp bulb, as illustrated in Fig. 1 herewith. The illustration shows two filaments, each of which is of the familiar double-coil or loop type. These are mounted in the usual way at one end of each filament, the other ends of the two are joined by being cemented to a third wire, 3, sealed into the glass mount or stem, but not passing through it. It is necessary for successful exhaustion that the three cemented joints should be equally heated, so that the gases and hydrocarbons will be thoroughly expelled from all of them. In order to obtain this result, the heat-emitting property of the joints at the junction of the two filaments is reduced by making the supporting wire, 3, of smaller diameter than the leading-in wires, 4 and 5. The two filaments being connected at the one point add their heat, and the decreased capacity of the joint to dissipate the heat brings the temperature to an equality with that at the other joints. The loop of each filament is shown anchored in the usual manner to iron wires sealed into glass prongs. Patent No. 726,929.

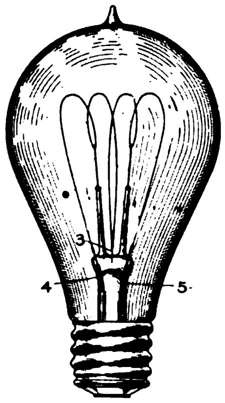


FIG. 1.

Electrical Testing Apparatus.—It has long been recognized that for convenience in shop and repair work a testing outfit comprising an induction coil and telephone receiver is far preferable to more elaborate and more accurate instruments. Fig. 3 herewith illustrates a very compact testing apparatus of this character, which has been patented by Harry A. Lewis, and Fig. 2 is a diagram of the circuits. In the diagram, *B* represents a battery cell; *C*, an induction coil of the ordinary type minus the vibrator; *D*, an individual electromagnetic interrupter; *E*, a condenser connected across the contacts of the vibrator in the usual fashion; *F*, a switch for connecting the telephone receiver, *H*, in series or in parallel with the testing terminals, and *g*, *g*, the terminals. The battery, induction coil, vibrator, condenser and switch are enclosed in a case, as shown in Fig. 3, and the switch is thrown from one side to the other by means of two push buttons projecting from the top of the case. The functions of the handles, *g*, *g*, will be obvious to anyone who has ever used a telephone for testing out short-circuits, "grounds" or open circuits in electrical machinery. This is the class of work, of course, for which the outfit is intended by the inventor. Patent No. 723,205.

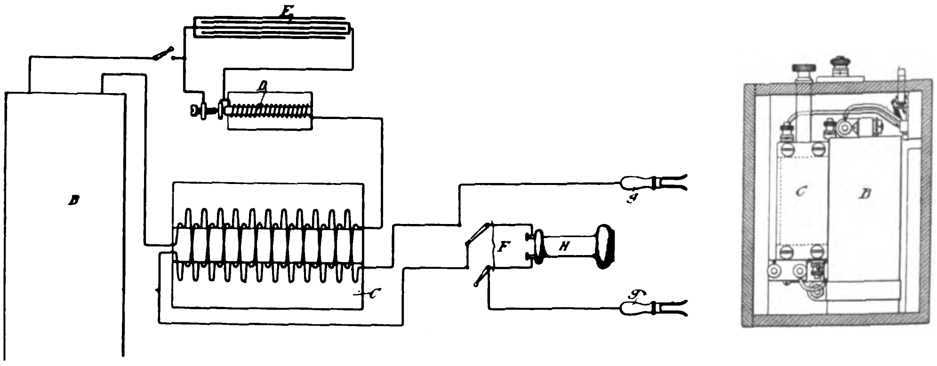


FIG. 2.—ELECTRICAL TESTING APPARATUS.—FIG. 3.

Combined Generator and Motors for Automobiles.—Figs. 4, 5 and 6 herewith illustrate an arrangement of electrodynamic apparatus which is ingenious whether commercially practical or not. The invention comprises a dynamo and two motors having a single field-magnet structure but provided with individual field-magnet windings and armatures, of course. This arrangement is intended for use on the class of vehicle which is provided with a prime mover, usually in the shape of an internal combustion engine, intended to drive a dynamo constantly, one or more motors being operated by the current from the dynamo. A plan view of such a combination is shown in Fig. 5, and Fig. 6 shows an elevation of this same running gear. In these illustrations, the dynamo, which is the central machine, has four field-magnet poles and the motors are bipolar. The structure shown in Fig. 4 makes all of the machines bipolar; the generator armature, as in the other case, rotates in the central circular chamber and the motor armatures in the other two. The field windings are intended to encircle the round cores shown in the engraving, so that all of the dynamo field winding affect the field strength of the motors as well as that of the dynamo. Individual field regulation of the motors, however, is obtained by means of the coils on the smaller cores, *9-b*. The chief advantage claimed for this construction is, of course, a reduction in the weight of the total equipment as compared with an individual dynamo and motors. Another advantage claimed by the inventor is that the driving shafts may be tilted as indicated in Fig. 6, since they are geared separately to the two motor shafts. Patent No. 725,675.

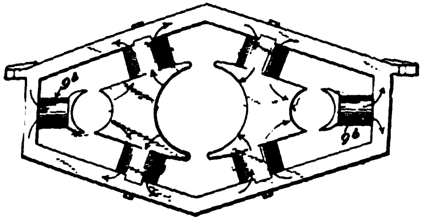
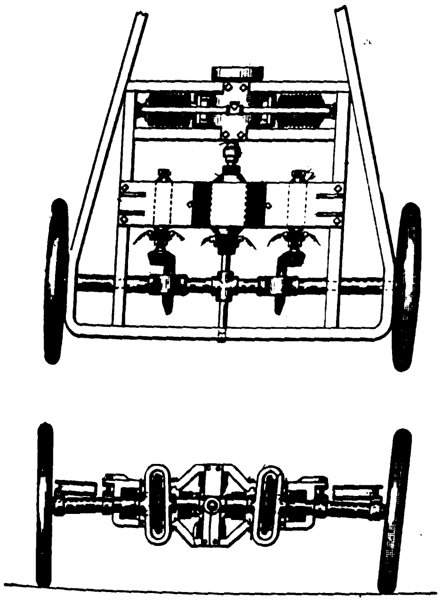


FIG. 4.—COMBINED MOTOR AND GENERATOR FRAME.



FIGS. 5 AND 6.—PLAN AND ELEVATION OF COMBINED GENERATOR AND MOTOR.

NOTES.

Catalogues Desired. The Institution of Engineers on the River Plata, located at Buenos Ayres, Argentine Republic, desires to receive catalogues from manufacturers of machinery, mechanical and electric appliances, tools, etc., to be filed in its library. The headquarters of the institution are at Calle 475 B. Mitre.

Automobile Omnibus in London.—According to a cable dispatch published in one of the New York papers the automobile omnibus built by the Fischer Company for the London General Omnibus Company was given a trial early last month and proved very satisfactory. The trial run covered approximately 25 miles, and it is said that the facility with which the huge vehicle was made to tread its way through the crowded traffic of Piccadilly Circus, Regent Street and Oxford Street, was most remarkable. The power equipment of the omnibus consists of a combined gasoline engine and reversible dynamo-electric machine.

International Electrical Congress.—The International Electrical Congress which is to assemble at St. Louis next year will probably be held during the week of September 12-17, in order to accommodate college men and delegates from foreign countries, and to allow those who so desire to stay over and attend the International Congress of Arts and Sciences, which is to be held during the week following the dates mentioned. It appears that most of the international electrical associations will assemble in St. Louis during this week, and the Exposition Company will accommodate them all with free convention halls, and grant free admission to the grounds on certain special days.

National Club House for Engineers.—A movement to establish combined headquarters for the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining Engineers, and the Engineers' Club of New York City, has received a substantial impetus by an offer from Mr. Andrew Carnegie to give one million dollars for the erection of a suitable union building for these organizations. The desire to provide such a building has existed among the prominent members of the various associations for several years, and through Mr. Carnegie's munificence this plan appears to be well on the way toward fruition.

American Institute Annual Convention.—The annual convention of the American Institute of Electrical Engineers will be held June 29 to July 3 at Niagara Falls, and some interesting papers have been promised thus far. These include a paper on "The Storage Battery in Sub-Stations," by W. E. Goldborough and P. E. Fanslar; one on "Alternator Design," by W. L. Waters; one on "The International Electrical Congress of 1904," by Prof. Elihu Thomson; one on "The Magnetic Unities," by Dr. A. E. Kennelly; one on "Testing Electrical Apparatus for Dielectrical Strength," by Percy H. Thomas, and one on "The Delta and Y Connection of Transformers," by F. O. Blackwell. The annual business meeting of the Institute was held on May 19, so that the convention proceedings will be restricted to the reading and discussion of papers. Visits will be made, of course, to the many local places of engineering interest.

Swiss Railways to be Electrically Equipped.—The introduction of electric traction on Swiss railroad lines was discussed at length at the convention of the representatives of these lines, and prominent technical experts of the State held recently at Berne. The convention appointed a special committee to investigate the subject thoroughly and render a report next year, with recommendations as to the adoption of the most practical mode of applying electricity to these railroads. The committee has been supplied with funds sufficient to enable it to make practical tests, so as to eliminate any uncertainties in the report. The prime object in considering the equipment of the railroads is to save the large amount of money paid annually for coal imported from Germany, Switzerland being without any coal mines of her own, but having ample water power with which to operate electric generating stations.

Reducing the Noise on Elevated Railways—Interesting experiments are in course of prosecution on the Berlin elevated electric railway built by Siemens & Halske and opened for traffic last year. The road has proved a remarkable success commercially, but complaints are loud and numerous concerning the noise incident to the travel of the cars over the elevated structure. The first effort made to get rid of the noise consisted in inserting three layers of felt between the rails and the wooden cross-ties on which they were laid. This was inadequate, however, although it gave some improvement. Next hollow iron girders filled with loose sand were substituted for the wooden sleepers; this also was partially effective, but not entirely so. The rails were then laid on long longitudinal sleepers with cushions of lead under them, eliminating the cross-ties, and finally the car wheels have been lined with wood so as to break the continuity of the path for vibrations through metal. These experimental remedies are still on trial, but no conclusions concerning them have been announced.

Electricity for Gas Works Operation.—An interesting gas power plant is now being installed at the works of the Milwaukee Gas Light Company, Milwaukee, Wis. The company is erecting a new gas works which will be one of the largest in the country, and will embody the most advanced practice in modern gas engineering. Although no electricity will be generated for outside lighting, a gas engine-driven electrical plant will be employed for furnishing motive power to the various auxiliaries throughout the works, all of which will be operated by electric motors. A large machine shop will also be operated by electric motors. Coal will be unloaded from boats elevated to the storage bins by electrical hoists and conveyors, the retorts will be charged and drawn by electrical appliances, and the final disposition of the coke will be accomplished by means of electric power apparatus. The entire electrical distribution system will operate at 250 volts, direct current, from a central power generating plant, driven by gas engines supplied from the gas mains. The present equipment comprises a 250-h.p. Westinghouse horizontal double-acting gas engine, driving a 150-kw dynamo, and three 125-h.p. vertical engines, belted to 75-kw. dynamos. Provision has been made for future extensions of the equipment with a second unit of the horizontal type. This engine is of the new type recently introduced by the Westinghouse Machine Company and described in these columns.

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CONTENTS.

Central Station at De Kalb, Ill., by J. R. Cravath 251
Steam Turbine Efficiency, by W. T. Edwards 255
Some Points Regarding Boiler Practice in Electric Light and Power Stations, by Geo. H. Barrus 256
Steam Engines for Electric Power Stations, by Geo. I. Rockwood 260
Steam Plant Auxiliaries, by Henry C. Meyer, Jr. 261
Steam Piping in Modern Power Plant Practice, by Chas. W. Oliver 262
Electric Haulage on French Canals, by Geo. E. Walsh 266
American Steam Engines for Electric Light and Power Service, by H. F. Schmidt.. 267
Abstracts from Foreign Contemporaries 305
Some Recent Electrical Patents 308
Notes 309
Editorial 310
Design for a 150-ampere Electroplating Dynamo, by C. P. Poole 312
Common-Sense Terminals and Binding Posts, by E. E. Warner 315
Intercommunicating Telephone Systems, by A. Dallam O'Brien 316
Induction Motors for Elevators, by A. B. Weeks 318
Lessons in Practical Electricity 320
Letters on Practical Subjects 321
Queries and Answers 322
Air-Compressors for Railway Brakes 323
New Apparatus and Appliances 324
Resistance Required in Series with an Incandescent Lamp to Produce a Given Candle-power 327
A Smith Storage Battery Installation 327
New Books 328
Obituary 328
Personal 328
Trade Publications ....Adv. 89
Business News ....Adv. 89

Progressiveness in Small Stations.

Owners of small central stations are beginning to realize that the old adage concerning the advisability of doing all things well applies to the management of electric light and power plants of modest size as well as other things, and from recent reports one is inclined to credit the Western stations with awaking to this realization somewhat ahead of those in other sections of the country. We are hearing a good deal nowadays about the progressiveness of Western central station companies and managers of the very numerous class under discussion. Among these wide-awake managements is that of the DeKalb plant briefly described in this number; the broad policy of this company might very advantageously be emulated or even copied literally by managers of many plants of three or four times the size of this one. Among the more conspicuous progressive features may be noted the provision of a display room where present or prospective customers may find an array of fittings and subordinate apparatus of the grade carried by first-class supply houses, the character and quantity being restricted, of course, to such as the service justifies. The operation of the municipal waterworks pumps is another feature far from common in Eastern plants, and one that should be cultivated by all stations in cities of moderate size. Of course, when a waterworks requires pumping engines of hundreds or thousands of horse-power, electrical operation is thoroughly unpractical, although perfectly feasible.

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Central Station Steam Practice.

The series of articles on this subject, by well-known authorities, which appears in this number will well repay careful perusal and preservation for re-reading. The subject is so broad that a complete discussion of all its phases would be impracticable within the limits of the space available in any periodical; the vital points, however, have been treated with surprising thoroughness, considering the space actually occupied by the articles. It was contemplated to include in the series articles on stoking and furnace draft, and arrangements were made for these to be written by recognized authorities; but, unfortunately, unforeseen conditions arose which prevented the consummation of this plan.

A review of this complete series is impossible within the limits of these two pages; moreover, the writers have all treated their subjects so soundly and conservatively that there is not much room for comment beyond recording a general acquiescence. Mr. Rockwood's well-known partiality to large cylinder ratios and the simplest possible valve gear comes out prominently in his discussion, and he brings out a point concerning superheat which is too frequently overlooked—namely, that the cost of superheating the steam may counterbalance or even exceed the saving in fuel represented by the increased engine economy considered alone. The gentle dig administered to designers of stationary engines, in the comparison of land and marine practice, should also cause some hard thinking; and Mr. Rockwood's closing paragraph would doubtless incite an enthusiastic discussion if delivered orally and elaborated in the hearing of some well-known engine designers we could name—a discussion which we should thoroughly enjoy hearing.

There is just one joint in Mr. Meyer's remarks on auxiliaries which gives pause to our acquiescence—that is, concerning pumps. We have an indistinct recollection that some one figured out once that it would pay to use live steam to help heat the feed-water, and to drive the pumps electrically, rather than work the ordinary steam pumps; we also have a most vivid recollection of exhaustive efforts in our callow youth to cajole into sustained operation one of those steam-driven air pumps which Mr. Meyer says are not likely to get out of order. But they do build them better now; it is but fair to concede that. The bugbear of inability to work an electric pump motor at any desired speed, however, which is so frequently put forward, is wholly imaginary.

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Electrically Driven Pumps.

Whether used for boiler feeding, waterworks service, or other classes of work, the successful operation of a motor-driven water pump will depend largely upon the type and power of the motor. It will not usually suffice to hazard a guess at the amount of power required and then hitch on the first motor of that power that one chances to run across. Whether direct-geared or belted, the armature should be of extra substantial construction, capable of withstanding sudden torsional shocks, and having an almost absurdly large shaft. If belted, the pulleys and belts should be calculated for at least double the rated output of the motor. The capacity of the motor should be certainly 25 per cent. greater than the full-load power actually required by the pump, in order to have a substantial reserve for forcing in emergencies, and 50 per cent. excess would not be extravagant in cases where no reserve pumps are installed. An important factor in water pumping is the friction loss in the pipes, and this should, of course, be added to the power required to lift the water and overcome the friction of the pump. In this, as in many other cases, experiment is the most reliable method of ascertaining the proper size of motor to install, where the power required is relatively small—say five to twenty-five horse-power. The power required may be roughly estimated by calculating the net power necessary to lift the water and deliver it, if delivered against pressure, and adding to this ten per cent of its value as an allowance for friction. This will give an idea of the size of motor necessary for making the test to determine the actual power required by the pump.

For driving boiler feeding and condensing pumps, a well-graded speed range is essential, of course, since spasmodic operation is highly unsatisfactory in the one class of work and impracticable in the other. It seems superfluous to say that this requirement is met in direct-current motor design without the slightest difficulty; this fact has been publicly stated and demonstrated so often that it would seem impossible that any one in touch with engineering should not know it. Nevertheless, we continue to hear occasionally that a serious disadvantage of motor-driven auxiliaries is the lack of speed control. With examples of speed control embodied in machine-tool and railway-car motors on every hand, argument as to its practicability is unnecessary, but it may be of interest to some one to say that the combination of double armature windings and variable field strength has been proved over and over again to give a speed gradation that should meet the requirements of the most difficult pumping problem that ever occurs in actual practice.

Transformers on Different Frequencies.

Once or twice during the past four years we have explained what happens to a transformer when the frequency of the supply current is changed, but requests for an explanation of this case have been received so frequently of late that another effort appears to be justified. The primary winding of a transformer gives a counter e.m.f. which must almost equal the impressed primary e.m.f. This counter e.m.f. is numerically proportional to the product of magnetic lines of force in the core, number of cycles, and turns in the primary winding. Now if a transformer built for 120 cycles and any given voltage be put on a 60-cycle circuit of the same voltage, it would appear that since the number of cycles is one-half the rated number, the counter e.m.f. will be reduced one-half, and the current doubled. This is by no means what happens. On the contrary, the counter e.m.f. is so nearly the same as before that the difference would be difficult of measurement. The magnetic flux, however, is practically doubled, this being accomplished automatically by an increase in the "no-load" or magnetizing primary current, which is consequently about three times as great as that required on 120 cycles. If the permeability of the transformer core iron remained constant, the magnetizing current would need to increase only in proportion to the increase in magnetic flux; but with an increase in flux density, the permeability decreases, requiring an extra increase in magnetizing current. The net results, therefore, of changing the circuit frequency from 125 to 60 cycles will be approximately to double the magnetic density in the core and to increase the magnetizing or no-load primary current by about 200 to 250 per cent..

Inasmuch as the magnetizing or no-load primary current is, at the worst, only a trifling proportion of the full-load primary current, increasing it two or three hundred per cent. is not such a serious matter as these figures might appear to indicate. The increase in core losses entailed by doubling the magnetic density is included in the increase in magnetizing current; the loss due to hysteresis will be about one and one-third as great as before, while the loss due to eddy currents will be unchanged, the magnetic density having increased in practically inverse ratio to the decrease in frequency. The increase in power losses, as distinguished from increase in primary current, therefore, will be approximately thirty-three per cent in the core and less than one per cent in the primary winding at full load—a total increase of about thirty-four per cent in full-load losses. If the transformer showed losses of three per cent on 125 cycles, therefore, the losses at 60 cycles will be about four per cent; this is the only additional load to which the transformer will be subjected.

Isolated Plants vs. Central Station Service.

As in most other branches of industry, engineering practice is largely a matter of habit, so far as non-fundamental considerations are concerned, and the "habit" as to any particular feature is frequently established by a more or less temporary set of conditions; continuing, however, until some more than ordinarily logical mind either points out the flaws in the prevailing practice or discovers that the conditions which gave it birth have disappeared and left nothing to justify it. For example, it was for several years the habit to put in isolated plants in preference to using central station service, no matter whether the establishment required a 10-h.p. or a 500-h.p. generating equipment. It is highly probable that this tendency received its initiative in the days when central station service was somewhat unreliable (we can afford to confess it now) and there was a real advantage in being able to control one's supply of electricity, regardless of economy in generation.

The habit being once formed, it continued, like the bipolar dynamo habit in Great Britain, until checked by persistent common-sense argument and practical demonstration on the part of a few—very few—engineers having more analytical talent than imitative faculty. The ill-advised installation of isolated plants was carried to such an extent that one frequently hears now of the discontinuance of the generating equipment in such plants because experience has proved that it is cheaper to use central station service than to operate one's own generating equipment. Several such instances have been made public recently, some of the discontinued equipment being as large as 100 kilowatts.

There is not the slightest intention on our part to intimate that all isolated plants have been installed recklessly, or that the use of local generating equipment is bad practice generally. It is wholly a question of operating cost and central station charges, wherever reliable central station service is available; and it is a fairly safe generalization that an isolated plant of less than 100 horse-power actual duty cannot compete with the service from a well-managed central station. Obviously the dividing line is widely different under different conditions. In a building requiring a heating plant of considerable magnitude, for example, a much smaller generating plant may be operated profitably in comparison with the cost of central station service than would be possible if the heating plant were very small or non-existent. This is a very important factor in the problem of operating a commercial heating system in conjunction with a central station, and should have the most careful attention by station managers when considering the probable advisability of undertaking public heating. With heat service available from a central station, owners of business buildings and blocks have far less incentive to install isolated lighting plants than otherwise.

DESIGN FOR A 150-AMPERE ELECTROPLATING DYNAMO.

BY CECIL P. POOLE.

The accompanying engravings are reproductions made from working drawings for the construction of an electroplater having a capacity of approximately 150 amperes at 6 volts. Figs. 1 and 4 are assembly drawings of the machine, the latter being a complete axial section. The yoke-ring is of cast-iron, and it is intended that the magnet poles shall be made of round wrought iron of the size and shape indicated by Figs. 1 and 2, and cast-welded into the yoke-ring. The pole-face curve shown at the right-hand end in Fig. 2 is intended to be machined before the poles are cast into the yoke; this may best be done by mounting the cast-iron pole piece (Fig. 3) on the end of each of the poles, clamping the four poles in a jig and boring out the pole-faces. Care must be taken that the distance from the left-hand end of the body of the magnet pole (Fig. 2) to the center of the pole-face curve is exactly 3¼ inches, as marked on the drawing, and when the poles and shoes are set into the mold, preparatory to casting the yoke-ring, extra care must be taken to see that the distance between diametrically opposite poles is 6½ inches, as specified in Fig. 1. It will be found a good plan to bolt the four poles to a central cast-iron drum so as to secure the proper alignment when they are set into the yoke-ring mold.

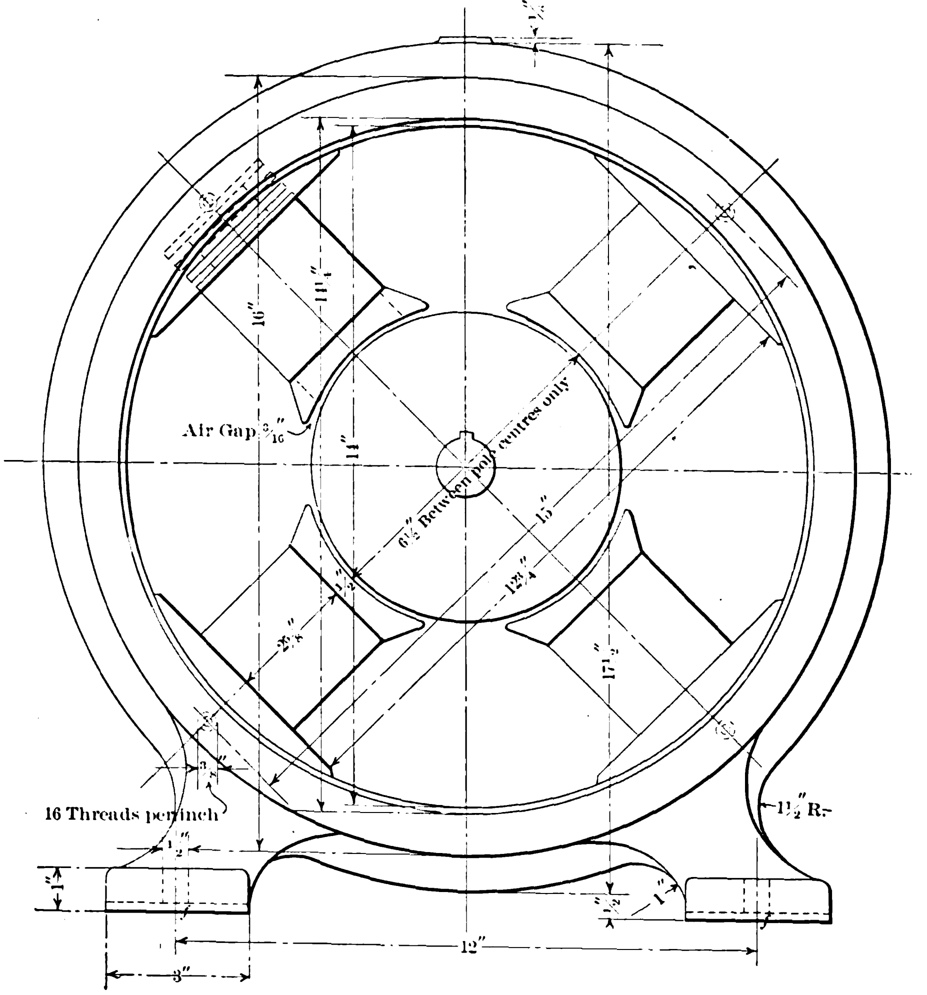

FIG. 1.—ELEVATION OF FIELD MAGNET FRAME.

Two journal box bracket patterns will be necessary, since the bracket at the commutator end must be extended farther out from the yoke-ring than the one at the pulley end of the machine. Fig. 5 is a face view of one of the bracket rings, both of which are identical from this viewpoint. The journal box housings are shown cast in a single piece with the pedestal bracket and having a thick web straight across the center horizontally, which is bored out to receive the bushing. This may be secured in place by means of a pin set into one side of the housing at a point midway between the oil ring slot and the end of the web in which the bushing is seated. This arrangement is not shown, it being thought best to leave the exact details of the construction to the individual fancy of the builder. It makes no difference, of course, what the details of the box construction are so long as the bore and length of the bushings are adhered to and a suitable projection is provided on the inner end of the right-hand housing in Fig. 4 to take the brush-holder quadrant. Fig. 6 shows the oil ring, which should be made of a rather hard grade of brass. The shaft shown in Fig. 8 may be made of ordinary machine steel.

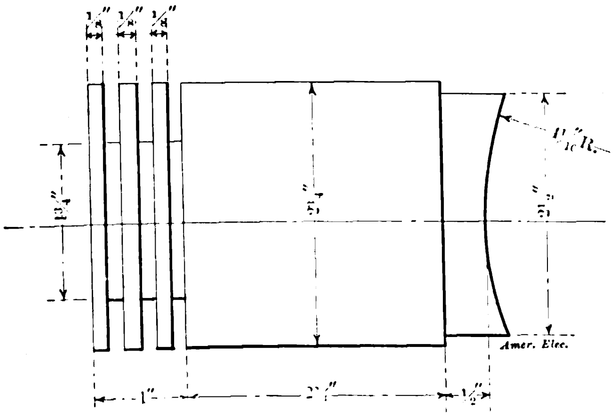

FIG. 2.—FIELD MAGNET CORE.

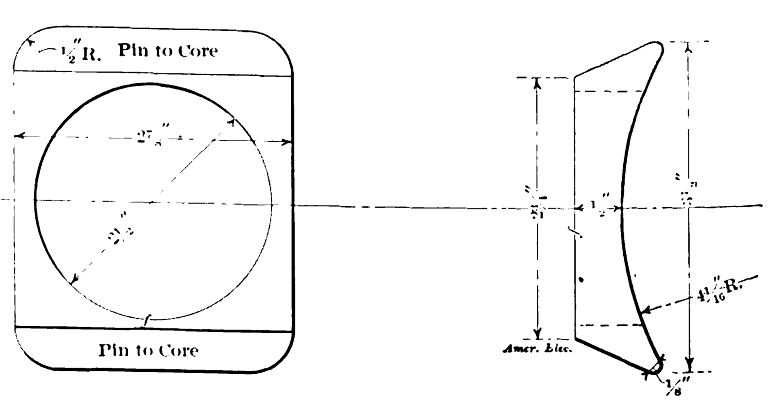

FIG. 3.—MAGNET POLE-PIECE.

The armature is of the usual drum construction, and the discs should be cut from sheet iron not more than 40 mils thick. The discs must be 6¼ inches in diameter and must have 41 slots, each 7-32 inch wide and ¾ inch deep, the sides of the slots being parallel with each other. The corners at the bottoms of the slots should be rounded to 1-16 inch radius in order to strengthen the teeth and also to increase the width of the magnetic path in the tooth at that point. The discs must be key-seated, as indicated in Fig. 1, the key-seat being ⅛ inch deep and ¼ inch wide. The key is to be ¼ inch square and without any taper, of course. The discs are clamped on the shaft between two heads of the size and construction shown in Fig. 9. These are cast-iron plates, each having a cylindrical flange extending axially from one side and being tapered on the outer face so as to form a slanted or tapered barrel for the support of the armature coils where they extend beyond the ends of the core.

As shown clearly in Fig. 4, the clamping head at the end of the armature toward the pulley backs up against the collar on

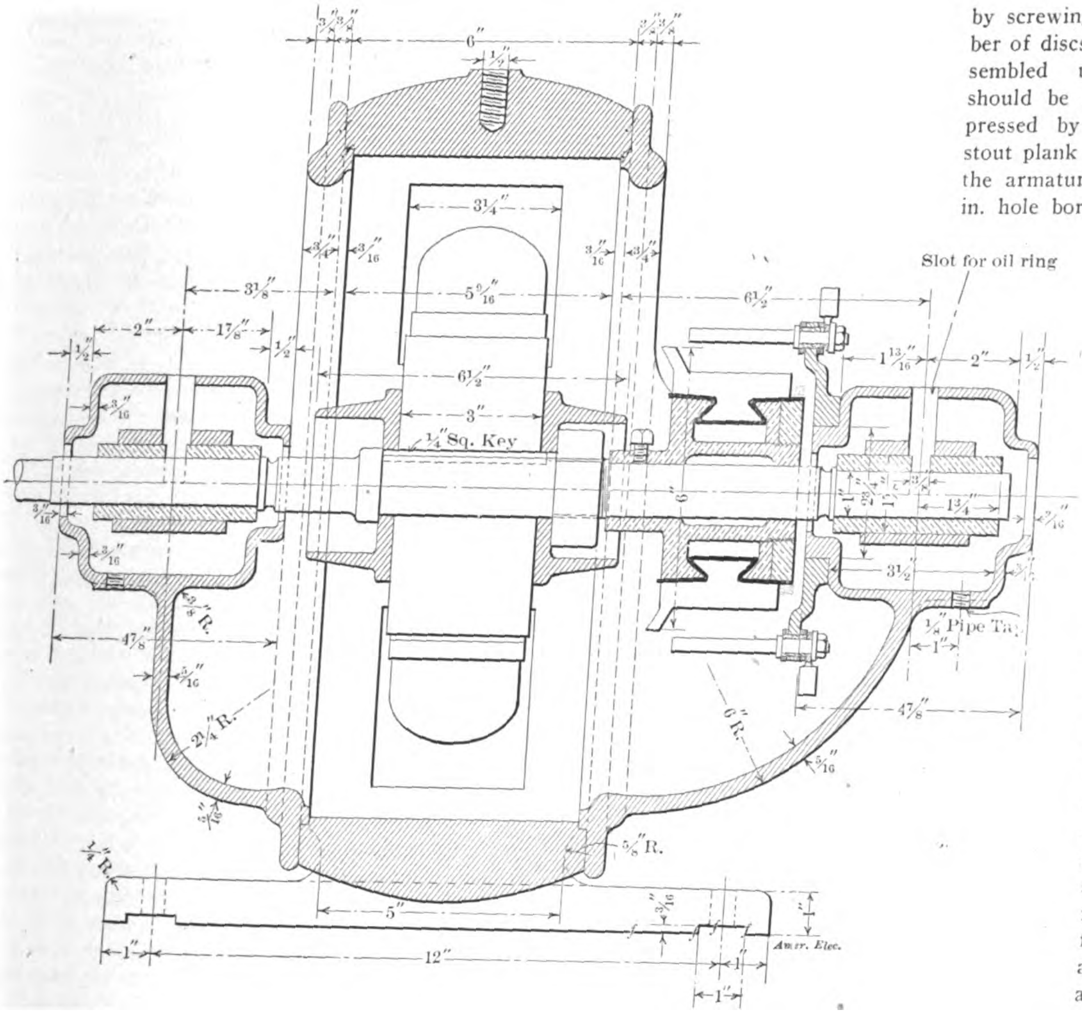

FIG. 4.—AXIAL SECTION OF COMPLETE MACHINE.

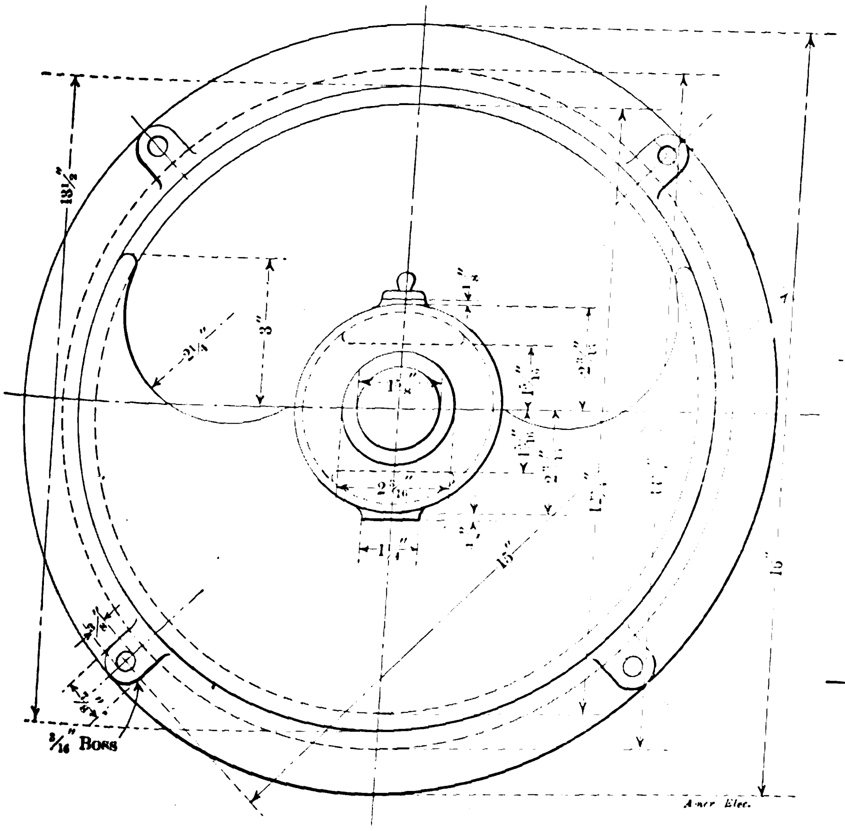

FIG. 5.—FACE VIEW OF JOURNAL BRACKET.

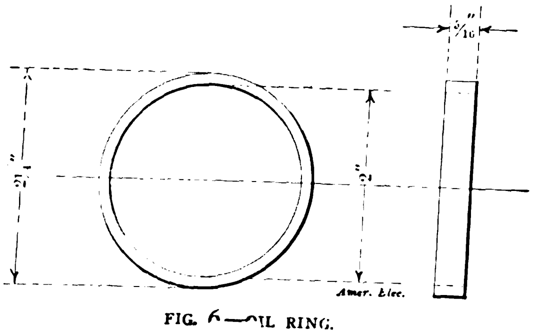

FIG. 6—OIL RING.

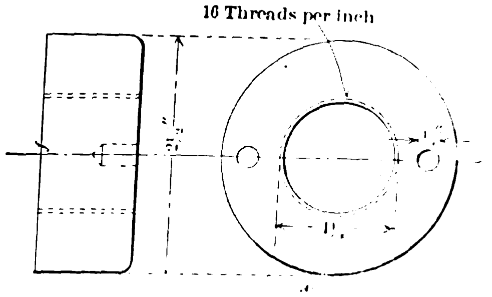

FIG. 7.—ARMATURE CORE NUT.

the shaft, and the one at the end toward the commutator is kept in place by the round nut shown in Fig. 7. It will not be advisable to attempt to compress the discs by screwing up this nut; the proper number of discs (to make a 3-in. core when assembled under considerable pressure) should be slipped on the shaft and compressed by screw pressure applied to a stout plank or beam laid across the end of the armature structure and having a 3¼-in. hole bored in it into which the barrel of the clamping end-plate may slip. After the discs are compressed to the proper position, the retaining nut may be put in place and set home with a spanner wrench having pins at right angles to the handle instead of pins set into the curved face.

The commutator, the details of which are shown in Figs. 10, 11 and 14, is intended to be 4 inches in diameter at the barrel and 6 inches over the lugs, but the diameter of the barrel may be reduced to 3 inches if preferred. The core (Fig. 11) may be made of cast-iron, but is preferably made of hard cast brass; this is also true of the clamping ring shown in Fig. 14. The segments must, of course, be made of copper, either drop-forged or cast; all of the axial and radial dimensions are shown in Fig. 10. The width of each segment at the face, measured circumferentially, as well as the taper of the segment from the inner edge to the outer, had best be left to the manufacturer from whom the segments are obtained; it is unwise for an amateur to attempt the actual construction of his segments. Segments may be obtained from any of the representative makers by specifying the number of segments, the diameter of the commutator barrel and the thickness of insulation between the segments, which should be 30 mils.

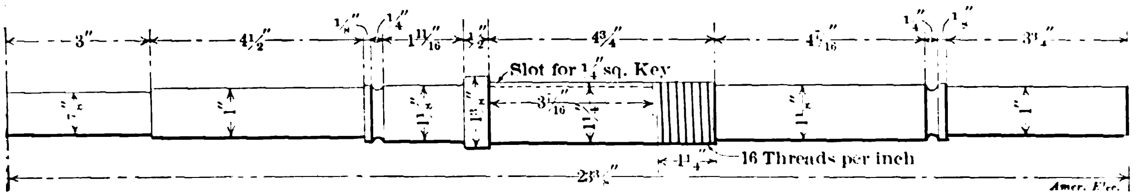

FIG. 8.—THE ARMATURE SHAFT.

In putting the commutator together, it will be found advisable to bore a hole 4½ inches in diameter in a block of wood 1½ inches thick and assemble the segments, together with the mica insulating strips, loosely within this hole. Then set the segments up tight by radial pressure from the outside, using a ring of either cast-iron or wrought-iron about 8½ inches in diameter at the lug end of the commutator and a smaller ring of 6 inches inside diameter at the other end; these rings each having eight ½-in. screws extending through them radially at equal intervals around the circumference, the screws pressing against eight segments of cast-iron, which in turn press the commutator segments together. The point of each screw should be bedded in a shallow hole in the center of the cast-iron segment against which it presses in order that the segments may not slip out from under the screw.

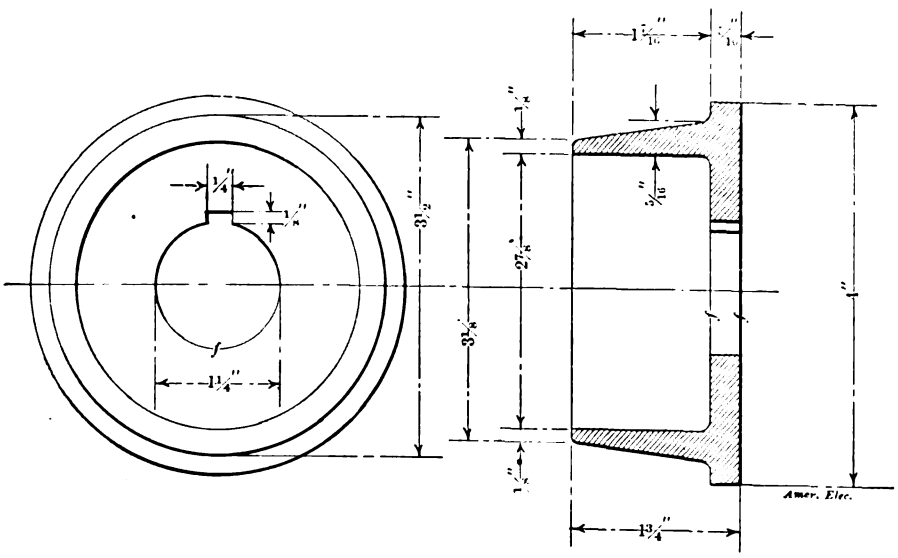

FIG. 9.—ARMATURE CORE END PLATE OR HEAD.

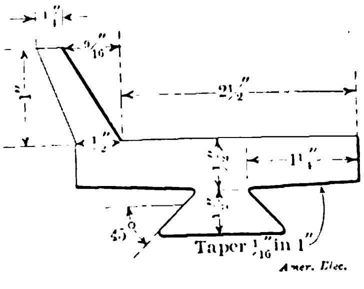

FIG. 10.—COMMUTATOR SEGMENT.

When the commutator segments have been compressed as tightly as possible, so as to form as nearly as possible a true circle, the complete structure as it stands should be chucked in a lathe and the ends machined to the proper tapers to fit the tapered ring on the commutator core (Fig. 11) and the clamping ring (Fig. 14). The core should then be inserted in the center of the mass of segments without removing the external clamps and the clamping ring (Fig. 14) put in place and clamped tightly by means of the nut. The external assembling rings and block may then be removed and the commutator mounted on a mandrel and turned true on the outer surface.

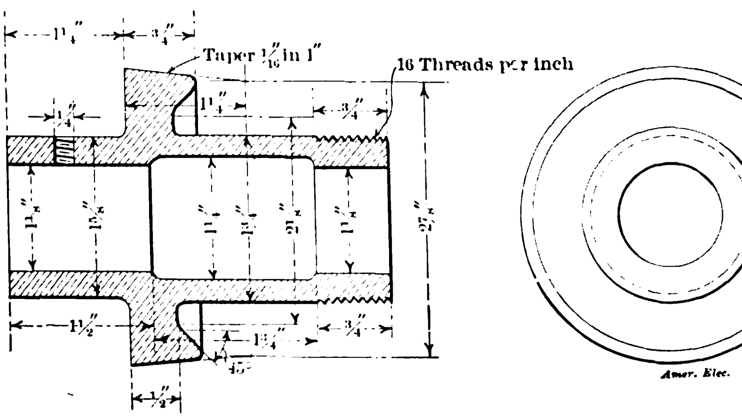

FIG. 11.—COMMUTATOR CORE.

Fig. 15 shows a convenient form of slide rail which may be used with the machine if belt adjustment is desired. The feet on the yoke ring of the machine have holes drilled in them to match the slots in the slide rail, as indicated in Figs. 1 and 4. It is intended simply to bolt the two slide rails down 12 inches apart from center to center and mount the machine on them, using screws in the lugs of the slide rails for adjusting the position of the machine.

The armature winding is of the straight-out or barrel type and consists of 41 coils of one turn each; each coil to contain two strands of No. 8 wire in parallel. The coils may be formed initially by taking two pieces of No. 8 wire 20 inches long and doubling them together in the center, one wire passing around the bend on the outside of the other, as indicated in Fig. 12. The two wires should be tied temporarily with very fine linen thread to hold them in place during the forming. They may then be bent to the shape shown by Fig. 13, the distance between the two parallel sides of the coil being made such that the coil can be put into two armature core slots between which there are nine teeth. After being bent to the shape shown, each coil should be given a single wrapping of oiled linen tape ¾ inch wide and 0.01 inch thick, wrapped so that each convolution laps over one-half of the preceding convolution.

When all of the coils have been made ready, the slots in the armature core must be insulated by means of troughs of pressboard 0.014 inch thick, and the barrel at each end must be given two layers of plain linen tape, heavily varnished after being wound on. The pressboard slot troughs must also be thoroughly varnished on both sides. The core should be put in an oven and baked until the varnish on the troughs and the taping is thoroughly dried out; only the best grade of orange shellac should be used.

The coils are put on the core in the usual manner, all of the under sides being put in the slots first and the upper halves pulled into place in proper sequence afterwards. The terminals of each coil must be connected to commutator segments between which there are 19 other segments; in the usual armature winder's parlance, each coil will be connected up 1 and 21. The portions of the winding which project beyond the heads of the core must be held down on the cast-iron barrels by means of a single binding of No. 18 brass wire at each end. A binding of No. 20 tinned iron wire should be put on the center of the core, with a layer of pressboard between the wire and the core. The bindings on the coil projections at each end should be insulated from the coils by means of three or four thicknesses of pressboard.

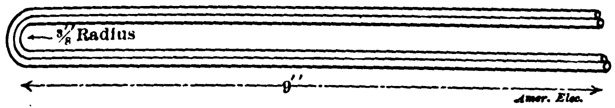

FIG. 12.—A COIL BEFORE FORMING.

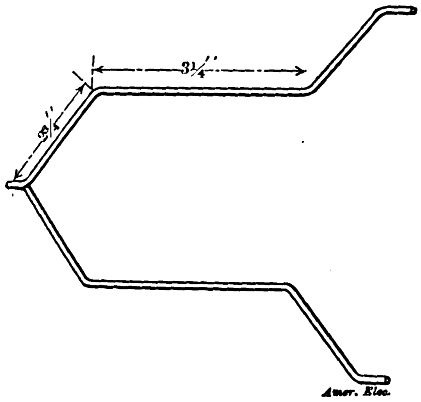

FIG. 13.—FORMED COIL.

The field winding consists of four coils of No. 7 double cotton-covered wire, wound to a depth of seven layers. Each coil should contain 100 turns of wire, so that the length of the coil parallel with the core will need to be approximately 2¼ inches. The four coils are to be connected in series and the entire winding is to be connected in shunt to the brushes, with a suitable rheostat in series, of course. The shunt field current will be not quite 25 amperes and the rheostat must, of course, be proportioned for this current. The coils should be wound on bobbins of either brass or fibre, the barrel of the bobbin being 3 inches in diameter externally, and the flanges or heads 5½ inches in diameter. If brass bobbins are used, these must be thoroughly insulated with varnished muslin or canvas before the coils are wound into them. The exterior of each coil should be covered with a layer of cord, the diameter of the cord being about 3-32 or ⅛ inch.

The brushes must be either of leaf copper or woven wire and each brush face must be ⅜ x 1⅛ inches. Four sets of brushes must be used, two brushes on each stem or rod, making eight brushes in all. The two sets diametrically opposite will be of the same polarity, of course, and must, therefore, be connected by means of a rubber-insulated flexible cable, which should be equal in conductivity to No. 0000 wire.

The principal electrical and magnetic data relating to the machine are as follows:

Revolutions per minute........	500
E.m.f. at brushes	6 volts
Delivered armature current	150 amp.
Shunt field current	25 amp.
Total armature current....	175 amp.
Current density in armature winding	3400 amp.
Current density at brush faces	147 amp.
Current density in field winding	1500 amp.

On account of the difference in magnetic quality of different irons, the speed may need to be changed. The proper speed may be ascertained by cutting out the field rheostat and speeding the armature at whatever speed is necessary to give 7 volts at the terminals; this should be taken as the running speed of the dynamo.

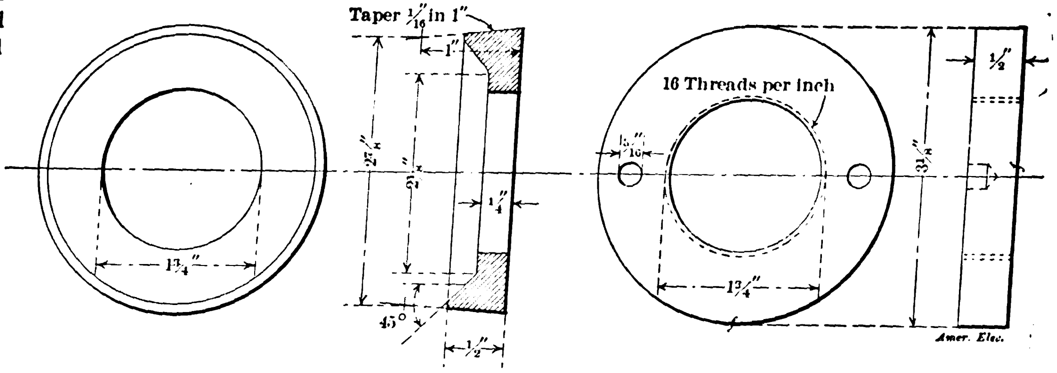

FIG. 14.—COMMUTATOR CLAMPING RING AND NUT.

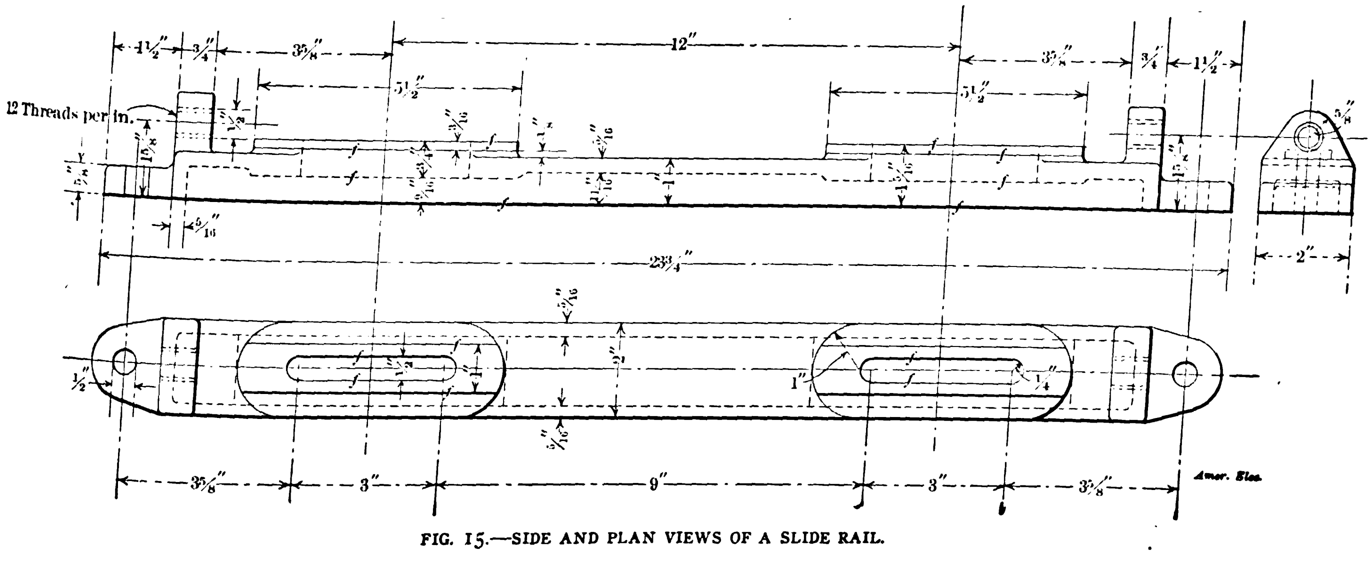

FIG. 15.—SIDE AND PLAN VIEWS OF A SLIDE RAIL.

COMMON SENSE TERMINALS AND BINDING POSTS.

BY ELMER E. WARNER.

An observation of the binding posts or plates supplied by various manufacturers of motor-controlling devices suggests the use of a little more common-sense in their construction. The ordinary form of round or rectangular post with a good-sized hole through it (supposed to be large enough for the largest wire used and often made much larger) and a set screw at right angles, to pinch the wire, makes about the poorest contact imaginable. The point of the screw beds into the copper, flattening it, sometimes fracturing it, and always tending to spring it away from the post at every other point, as indicated in Fig. 1. Furthermore, the contact is only a line practically

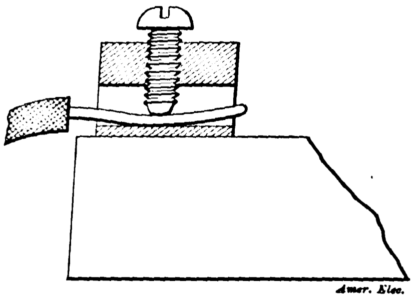

FIG. I.—ORDINARY POST.

between two curves of different radii. This applies especially to small wires, where lugs are not required or short connections where they are impractical.

A common-sense terminal may be either made of ½-in. round stock or ¼-in. by ⅜-in. flat stock, of any length required, as indicated by the dotted line, *A*, in Fig. 2. It has the advantages of being made from common bar brass, and being thick enough not to require drilling completely through for the two screws that clamp it to the base, and not to be warped by their strain. The clamping screw for the wire is a $^{14}/_{20}$ x ½-in. round head, of iron, either standard or under-cut at the head to two-thirds the depth of the thread, so that the brass washer which has a half-thread in it will not drop off when it is taken out. The rectangular post cannot turn, as it has two screws to hold it.

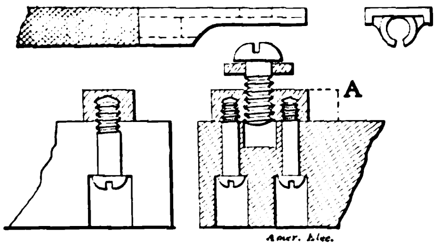

FIG. 2.—COMMON-SENSE TERMINAL.

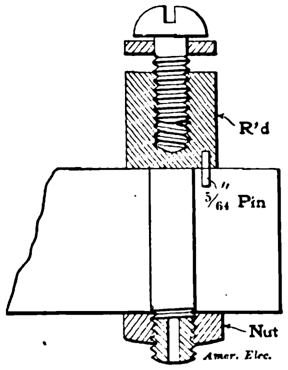

FIG. 3.—COMMON-SENSE POST.

It is self-evident, I think, that any wire smaller than No. 7 B. & S. will have much better contact if given nearly a full turn under the washer and screwed down hard, and it cannot be pulled out. For larger sizes, up to the capacity of the post, the terminal or lug shown stamped from 14 B. & S. sheet copper should be provided. This has a lip projecting over the edge of the post so that it cannot twist around, and the open edge of the solder cup is down when screwed to place, so as to leave the more finished side up. The round post, shown in Fig. 3, is straight monitor work, and cheaper, and as shown or with an extra nut, most convenient for back connections. These can be made on the rectangular type either by using an extra screw or by soldering directly in.

◆◆◆

INTERCOMMUNICATING TELEPHONE SYSTEMS.

The DeVeau Automatic.

BY A. DALLAM O'BRIEN.

The DeVeau automatic telephone system differs from most inter-communicating systems in that no induction coil is used in the talking circuit, the transmitters and receivers at the various stations being put directly in circuit with each other and with the talking battery. The instruments are wired for battery call and a common return which does duty for both ringing and talking

A low resistance vibrating bell is used for signaling purposes. The switching mechanism, shown by Fig. 2, is mounted on the interior of the box of the wall set, and in the base of the stand in the desk instrument, the only portion of the switch that is visible from the outside being the push buttons, each one of which represents a station. It is possible with this system to connect any desired number of stations together at the same time, and the number of separate connections that can be made is limited only by the number of pairs of stations.

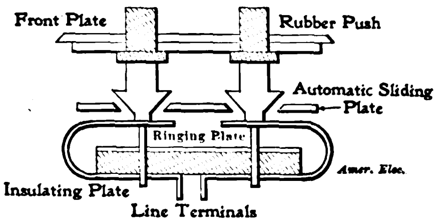

FIG. 2.—AUTOMATIC SWITCH.

In Fig. 2 is shown a detail of the automatic switch, which illustrates the manner in which connections are made and also the method of signaling. Before taking up the method of wiring, it will be advisable to examine into the construction and operation of the switch mechanism. The lines coming from the different stations are brought in through a hole in the back of the box in the case of the wall telephone, and are connected to the lugs mounted thereon, these lugs being clearly shown in Fig. 4. From this point on, flexible cable is led through the interior of the box to the automatic switch, and the lines from the different stations are there connected to the line terminals shown in Fig. 2. These terminals consist of thin metal springs, which are mounted on the hard rubber insulating plate shown in the figure, the spring being bent and having a hole drilled through its upper arm, through which passes the shank of the push-button, as illustrated. This shank is equipped with two collars, one of which keeps the line terminal spring in its normal position, the

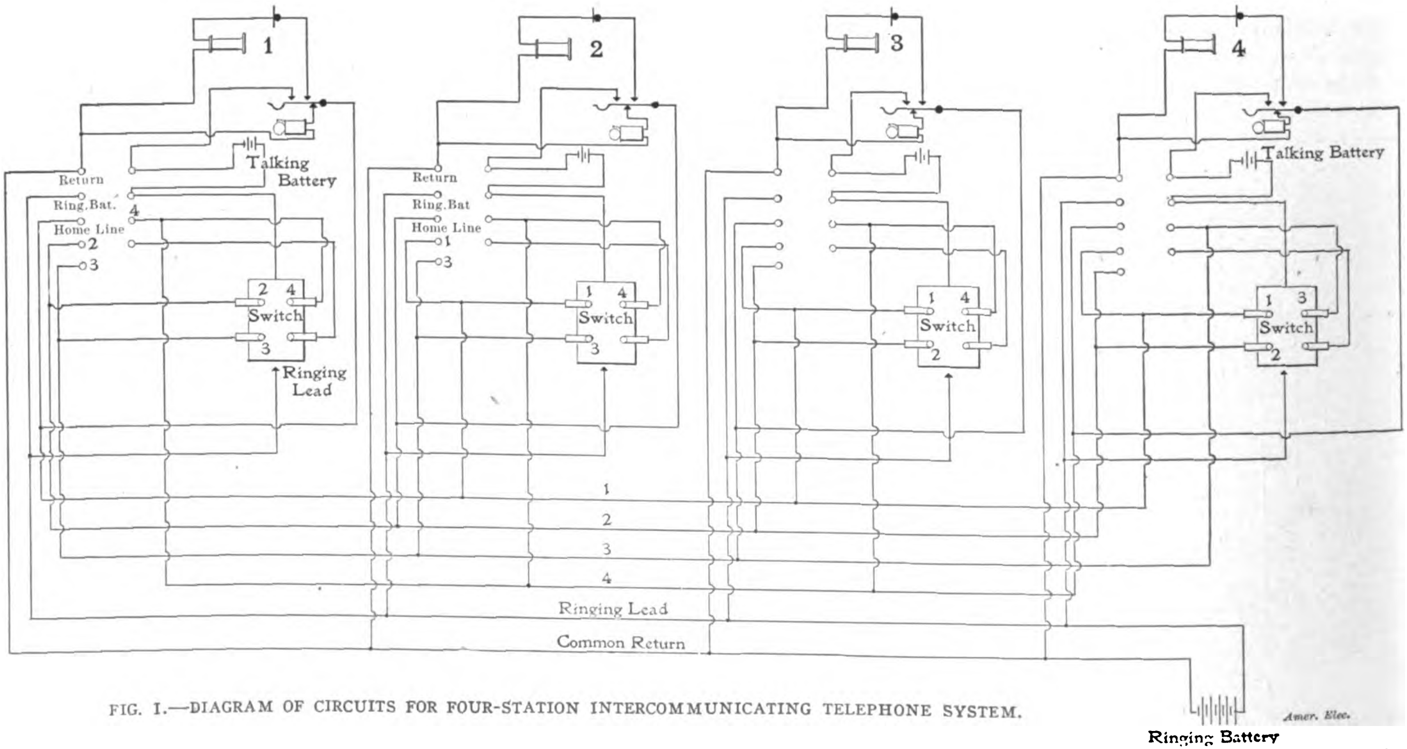

FIG. 1.—DIAGRAM OF CIRCUITS FOR FOUR-STATION INTERCOMMUNICATING TELEPHONE SYSTEM.

other one being arranged to engage with the sliding plate when the push-button is depressed. The sliding plate is provided with a spring, shown in Fig. 3, which tends to keep the plate always in the same position.

The act of depressing a button moves the automatic plate longitudinally against the tension of the spring, and when the upper collar has passed through the plate the spring draws the plate back to its normal position and locks the button, and at the same time makes a metallic connection between the upper collar and the plate. On the upper side of the insulating plate is mounted a metallic strip, or ring plate, to which is connected one terminal of the ringing battery, the sliding plate being connected to one terminal of the local talking battery. Fig. 1 is a wiring diagram which illustrates the general method of connecting the instruments in circuit, and from an inspection of this and from the explanation of the switching mechanism, given above, the operation of signaling and obtaining a connection should be readily apparent.

Suppose, for example, that station 1 wishes to call station 4; button 4 at station 1 is depressed as far as possible, thus bringing the line terminal spring, corresponding to station 4, in contact with the ringing plate, and ringing current flows from the battery through the plate and the line spring over line 4 to the hook-switch at the station, thence through the bell and back over the common return to battery, thus ringing the bell and signaling the station. Upon releasing the push-button, it springs back but is prevented from returning to its normal position, as has already been described, by the sliding plate, and at the same time the upper collar on the shank is brought into metallic contact with the plate. The receiver having been removed from the hook at station 4, current from the talking battery is allowed to flow from the sliding plate at station 1 through the shank of the push-button and the line spring of station 4, over line 4 to the hook-switch; thence through the transmitter and receiver, in series, and back over the common return to station 1, where the return circuit to battery is completed through the transmitter, receiver, hook-switch and contact points. This connects the transmitters and receivers at the two stations in series with the talking battery and the line, so that conversation may be carried on. When the receiver is placed upon the hook at the calling station, an arm pivoted on the hook-switch (shown in Fig. 3) engages with the automatic plate and moves it so that the button, which has been held in connection with the plate, is allowed to slip through and regain its normal position, thus clearing the connection. If, while two stations are engaged in conversation, it is desired to connect a third station on the same line, it is only necessary for the calling station to signal in the usual way to the additional station required, at the same time holding down the push-button of the station already connected to the line; otherwise, the pressing of the additional button and the consequent movement of the sliding plate would break the connection already established. Any number of additional stations may be connected to one line in this manner.

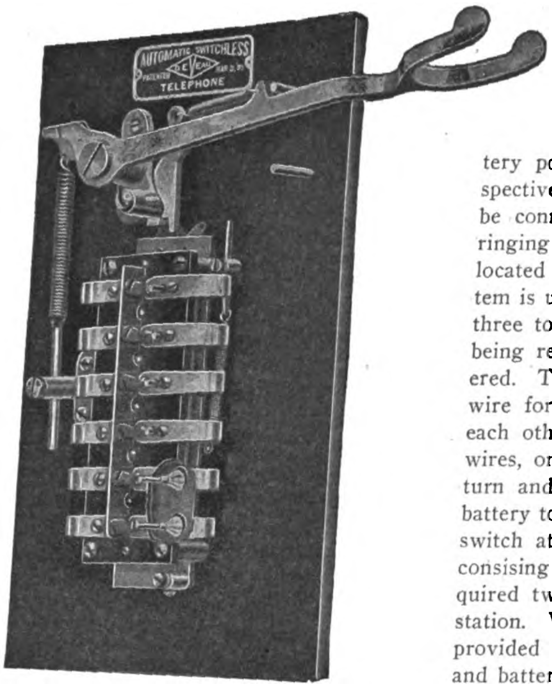

FIG. 3.—AUTOMATIC SWITCH.

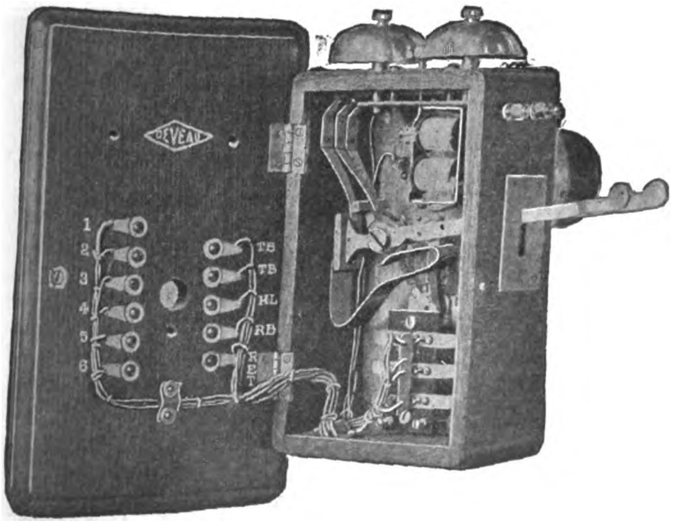

FIG. 4.—WALL SET, SHOWING INTERIOR.

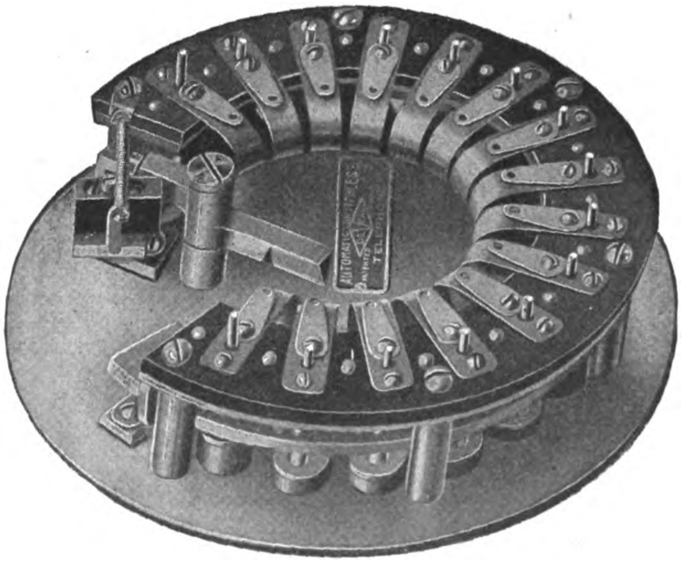

FIG. 5.—AUTOMATIC SWITCH FOR DESK SET.

Each instrument is provided with a local talking battery consisting of two cells of any good open-circuit wet or dry battery, and it will be noticed that the calling station in each case furnishes the entire battery power used for the connection, irrespective of the number of stations that may be connected to the line. For furnishing ringing current, a central ringing battery located at any convenient point in the system is used, this battery, consisting of from three to five wet or dry open-circuit cells, being regulated by the distance to be covered. The necessary wiring consists of one wire for each instrument, which is run to each other instrument, and two additional wires, one of which acts as a common return and the other to connect the ringing battery to the ringing plate in the automatic switch at each station. Thus in a system consising of ten stations there will be required twelve wires running through each station. With the desk instrument, there is provided a junction box wherein the line and battery wires are terminated, and from which a flexible cable is run to the automatic switch in the base of the stand. In many instances, a considerable saving in wiring can be effected by the use of a junction box in connection with the wall instrument, and the reduction in the number of wires entering the box and the consequent lowering of the chances for trouble would seem to justfy this practice in most cases. The liability of interference between simultaneous conversations is small, and in an intercommunicating system of this kind, need hardly be considered.

In Fig. 6 is shown a simple diagram of the talking circuit, which shows clearly the manner in which the instruments are connected and the method of furnishing talking current.

Fig. 3 shows a general view of the automatic switch and mechanism and also shows the means for adjusting the tension on the spring governing the hook-switch and the automatic sliding plate. These springs are fastened to the rods, as shown, and are adjusted by the use of the set screws.

Fig. 4 shows an interior view of one type of wall set showing the location of the connecting lugs on the back of the box and the opening for the entrance of the line wires or cables. The instrument shown in this illustration is not equipped with an automatic device for resetting the switch, and with this type of instrument when a button is depressed it remains in that position until restored by the depression of some other button, when it immediately comes back to its normal place. This feature does not, however, incapacitate either the instrument whereon the button is depressed or the instrument at the other end of the line thus connected.

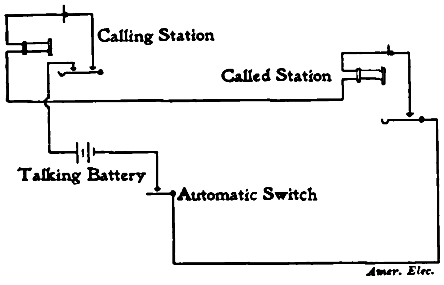

FIG. 6.—TWO STATIONS CONNECTED.

Fig. 5 illustrates the switching mechanism contained in the base of the desk stand, and shows clearly the mounting of the line terminals and the method of connecting thereto.

Fig. 7 shows the design of another type of wall telephone which is made entirely of metal and designed to be fastened to a wall or desk. This instrument is 5¼ ins. in diameter and 2¼ ins. deep, and is finished to match standard cabinet hardware. These instruments are manufactured by the Stanley & Patterson Company, of New York.

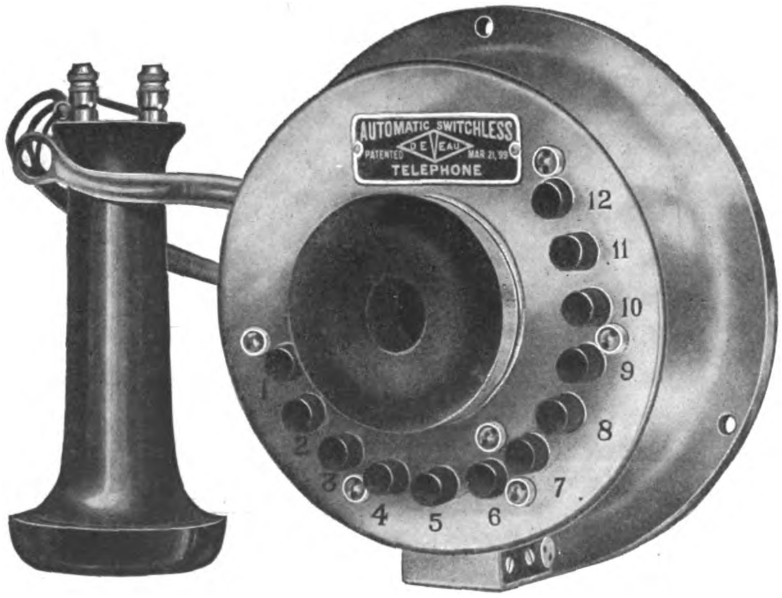

FIG. 7.—CIRCULAR BASE WALL OUTFIT.

INDUCTION MOTORS FOR ELEVATORS.

BY A. B. WEEKS.

Although many elevators are now operated by induction motors, little of a practical nature has been written on the subject. Therefore, a description of some of the apparatus employed and a few notes on the care of it will probably be of interest. In applying induction motors to elevators, two methods are employed, one being to couple the motor direct to the elevator mechanism, whereby it runs only when the elevator is in motion. This class of motor is started and stopped by a special controller operated by means of a cable passing up through the elevator car. The controller consists of a cylinder upon which are mounted contact blocks and resistance coils, and contact fingers pressing against the blocks. The cylinder is not keyed to the controller shaft, but is connected to it by a flat coil spring, so that when it is desired to start the elevator the operator simply pulls the cable up or down, according to the direction he wishes the car to go. This movement of the cable turns the controller shaft, and the spring acts to turn the cylinder, the speed of the cylinder being governed by a glycerine dash-pot, which is set to allow the motor to gain speed gradually.

The resistance coils used are made of flat strips of German silver, insulated between layers by good, thin mica, the finishing layer being soldered to the layer just beneath it. Several thicknesses of German silver are used, according to the resistance desired in each coil. In some of the coils there are two or three taps made at intermediate points, and these are connected to the proper contact blocks on the cylinder. As these coils are used only in starting the motors, they are intended to remain in the circuit only a few seconds; therefore, care should be taken that the cylinder does not "hang up" at an intermediate point and endanger the coils by keeping them in circuit too long.

If a coil should be damaged, it is well to remember that it is not necessary to disconnect all coils to remove one at the center of the cylinder. Should a coil at the center burn out, disconnect it, then remove the lock nut at the end of the cylinder and take off all the parts intact as far along as the disconnected coil. If micanite is used for rings between the coils instead of fibre, adjacent coils are much less liable to become damaged by a coil burning out. In replacing coils considerable skill will be required to connect them properly, so that there will be no short-circuits between the resistance strips, which must necessarily be side by side. Before placing new coils, one should be sure that the width, thickness and insulation of the strip is the same as that used on the old coil, so that the resistance will remain unchanged.

The care of the contact blocks and finger is also a very important matter. It is necessary to smooth not only the contact blocks but the fingers as well, as it is impossible to keep either in proper condition if the fingers are rough. If they are carefully fitted to the contacts and slightly lubricated, both will eventually acquire a hard polished surface which will seldom thereafter get in bad condition. If a small amount of vaseline is applied to the contact blocks frequently, and the dash-pot is kept in adjustment, there need be no fear of the cylinder stopping at intermediate points and burning out coils if the operator pulls the proper distance on the cable. In fitting the fingers to the contact blocks, a strip of emery cloth should be inserted between the finger and the blocks, with the rough side to the finger; then by pulling the cloth from side to side the finger can be cut down to the proper fit.

The contact blocks should never be filed crosswise, for this is sure to make hollows in which the fingers will be likely to lodge, and thereby prevent the full movement of the cylinder. When it is necessary to use a file on the contact blocks, always file in the direction of rotation. If any of the contact blocks are low, they may be raised by placing under them copper shims, which should have holes properly located, so the screws can pass through them and hold them in place. Always see that the contact blocks make good connection all the way across their surface. To avoid arcing and cutting of the contacts, increase the tension of the fingers at the adjustment screws, as more trouble is due to too little tension than otherwise. When it is no longer possible to give more tension by means of the adjustment screws, remove the finger and carefully bend the flat copper spring inward. This will permit the finger to be used until it is worn out.

Another very important thing to be looked after in an outfit of this type is the friction brake. It is necessary that the brake should completely release before the current is applied to the motor; otherwise the motor would not start readily, and as the current would be excessive the controller coils would soon burn out. If upon attempting to start the elevator the motor does not start, but gives out a humming sound like a large transformer, the trouble is likely to be a fuse out in one phase, or some finger not making contact, or too much load on the elevator car, if the brake has released properly.

Fig. 1 shows a development of the controller cylinder and the connections in general. The auto-transformers, one of which is used in each phase, are for the purpose of furnishing a low voltage for starting the motors. They consist of laminated iron cores, each having a single winding from which loops are brought out, so that any one of several voltages may be used when starting, the voltage being selected which gives the starting torque required by the work that the motor has to do. When starting, the end terminals of the coil, numbered 1 and 5, are connected to the mains, and the motor is connected to one main and one of the loops, either No. 2, 3 or 4, according to the torque desired; the higher the number used, the greater the torque. After the motor has approached its running speed, it is thrown directly across the mains, and the auto-transformer in each phase is cut out. The auto-transformers are connected at an intermediate point, usually loop No. 3, when they are shipped from the factory; if it is found that the motor starts very promptly, the connection may be changed to a lower point, say loop No. 2, and if it is then found that the starting torque is satisfactory, this lower point should be used; as the starting current taken by the motor is thereby reduced. The direction of rotation of the motor may be changed by transposing the wires of one phase.

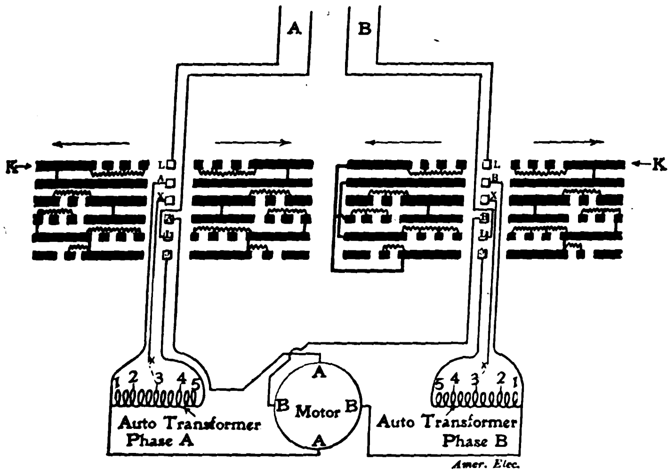

FIG. 1.—ELEVATOR CONTROLLER CONNECTIONS.

The second, and more common, method of applying the induction motor to elevators is to run the motor continually, belted to a counter-shaft from which a straight and a crossed belt run to pulleys on the elevator mechanism. In this case the cable which passes up through the elevator car is connected to the belt shifter, by which either the straight or crossed belt may be applied to the tight pulley of the elevator rig, according to the desired direction of the elevator car. In such a case, where the motor is usually run all day, a simple starting device is used, such as the auto-starter shown by Fig. 2. This consists of a double-throw switch mounted on a cast-iron box, in which are two auto-transformers. When the switch is thrown in one position, the auto-transformers are connected across the circuit and deliver a low e.m.f. to the motor. When the switch is thrown in the opposite direction, the auto-transformers are cut out and the motor is connected directly to the circuit. The wires from the power circuit are connected directly to the auto-starter, and the same number of wires connect the auto-starter to the motor.

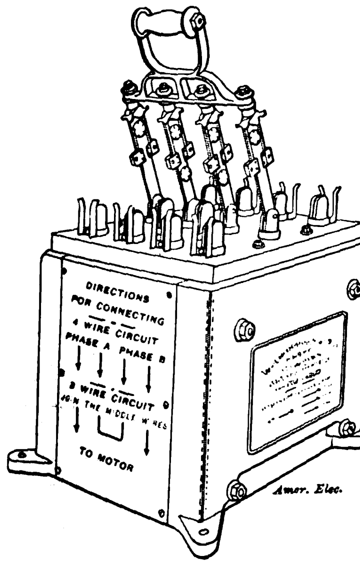

FIG. 2.—HAND STARTER.

Where elevators are used only a few times during the day, it is unnecessary to keep the motor running while the elevator is idle. In such cases, the switch shown in Fig. 3 may be used instead of the double-throw switch furnished with the auto-starter, as it accomplishes the same purpose and can be easily operated by means of a cable attached to the lever shown at the left, and passing from floor to floor, thus avoiding the necessity of going to the motor to start or stop it. This switch was designed for starting and stopping a two-phase induction motor, and its action is very similar to that of the controller previously described, except that it has two notches, the first connecting the motor to the auto-transformer loop, and the second connecting it to the mains. Fig. 4 shows the cylinder development and connections. Should the mechanism of which the flat coil spring is a part need to be repaired, it is an excellent plan to tie the spring together before taking the mechanism apart, so as to avoid uncoiling and perhaps breaking the spring. When the repairing is done care should be taken to replace the parts exactly in their proper positions, especially the spring, for if it is not put on right serious trouble may follow.

The automatic stop or "limit switch," for stopping the car at the top and bottom floors, may be readjusted when necessary to allow the car to go a little higher or lower, as the case may be, by loosening the locking nut and turning a little, with the direction of rotation. Do not make a mistake and set the wrong one. If, when stopped by the cable button or automatic stop, the car stops short of its landing, it may be caused by the friction brake becoming too hot. As soon as it cools off the car will stop at the proper place. With the type of elevator referred to above, it is very important that the worm gear should be regularly and thoroughly oiled, as there is always great friction with this style of gearing; hence the necessity of proper care. A cheap grade of castor oil is often used. Many elevators are so installed that it is almost impossible to oil them. For instance, the hand-hole, which is the proper place to apply the lubricant to the worm gear, may be backed up against a partition in such a way that it is inaccessible.

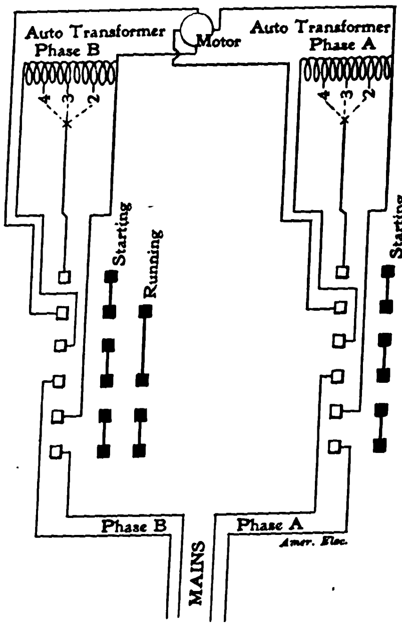

FIG. 4.—COMPENSATOR CONNECTIONS.

The stuffing-box and gear case joints should be sufficiently packed to prevent the lubricant from escaping. When packing the stuffing-box, do not force it enough to cause undue friction. Three pieces of packing, cut long enough so that when passed around the shaft the ends will almost touch, will be sufficient in most cases. The packing should be thick enough to fit snugly into the stuffing-box; place the first piece with the opening at the top, and the next with the opening at the bottom, and the last with the opening at the top.

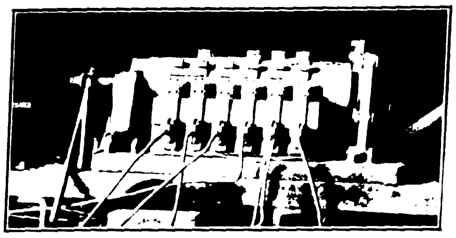

FIG. 3.—CABLE STARTER.

Lessons in Practical Electricity

THE NERNST LAMP.

The latest form of electric lamp put in actual service was invented by Professor Walther Nernst, of Göttingen, and is therefore known as the Nernst lamp. It has instead of the carbon filament of the ordinary incandescent lamp, a short strip of material which at ordinary temperatures is a non-conductor, but which at high temperatures becomes a fairly good conductor and a luminant. The "glower," as this strip is called, is made of mixture of oxides of magnesium, yttrium, zirconium, thorium and cerium; it is made up in small sticks, one of the standard sizes being about 0.03 inch in diameter and one inch long. As it is made of non-combustible material it is not necessary to enclose it in a vacuum.

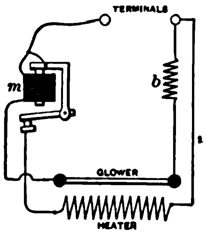

FIG. 1.—ELEMENTARY DIAGRAM.

As the glower is not a conductor at ordinary temperatures, a small coil of wire, heated by the passage of current through it, is employed to bring it to the temperature at which it becomes a conductor about 1750° Fahr. The heater coil is of fine platinum wire wound on a thin porcelain tube and imbedded in cement, the latter serving as a protection to the platinum wire from the intense heat of the glower after the latter has become white hot.

Fig. 1 shows a diagram of the lamp and connections, which shows that the glower and the heater coil are connected in parallel. when the lamp is thrown into circuit, current flows through the heater coil, which attains a high temperature and in a very few moments heats the glower to the conducting point. As soon as enough current passes through the glower to "light" it, the magnet, *m*, is strongly enough excited to raise its armature, breaking the heater circuit but leaving the glower in circuit. When the lamp is turned off, the armature falls back into the position in which it is shown in the diagram, and is ready for operation when the lamp is to be lighted again.

Since the resistance of material of which the glower is made decreases as the temperature rises, some means must be provided to prevent the fall in resistance from continuing to the point where an enormous current would flow and destroy the glower, and possibly the connections. This is accomplished by putting in series with the glower a resistance coil, *b*, known as the "ballast", and made of material which increases in resistance as its temperature rises, and thus compensates the fall in the resistance of the glower. The "ballast" is made of iron, which is used on account of its high temperature coefficient; that is, its rapid increase in resistance with rise of temperature. Consequently a point is soon reached at which any increase of current would increase the resistance of the ballast more than it would decrease the resistance of the glower, and when this condition is obtained no increase of current can occur, the lamp being invariably used on a constant-potential circuit.

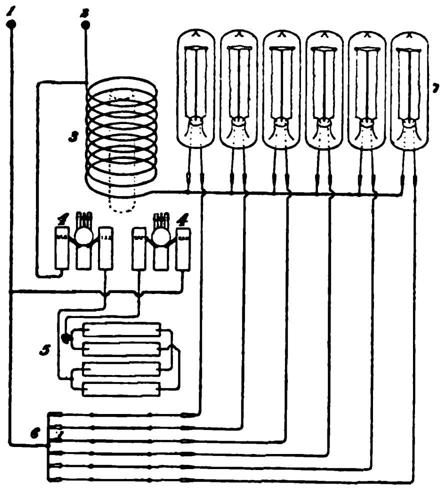

FIG. 2.—DIAGRAM OF CONNECTIONS FOR A SIX-GLOWER LAMP.

The glower is not subject to oxidation, but on a direct-current circuit it deteriorates rapidly because of electrolytic action, a black deposit being made on the negative end which extends gradually from the negative to the positive terminal. As this deposit increases the resistance increases, while the candle-power and efficiency fall off. With alternating current [*] there is no electrolytic action, but the glower deteriorates mechanically on account of the intense heat. The life of a glower on alternating current is from 400 to 800 hours, according to the rapidity of the current reversals; the life of the same glower on direct current would be much less. Most of the deterioration occurs just before the glower breaks, so that the candle-power remains high until near the end of its life.

Lamps are made with one, two, three, six and thirty glowers, all connected in parallel; these give an illumination of from 25 to 2,000 candle-power, and require from 1½ to 2 watts per candle-power. Fig. 2 is a diagram of connections for a six-glower lamp, in which 1 and 2 represent the line terminals; 3, the cut-out magnet coil; 4 and 4, a double-pole heater cut-out; 5, the heater; 6, the glowers; and 7, the ballasts, of which there is one for each glower.

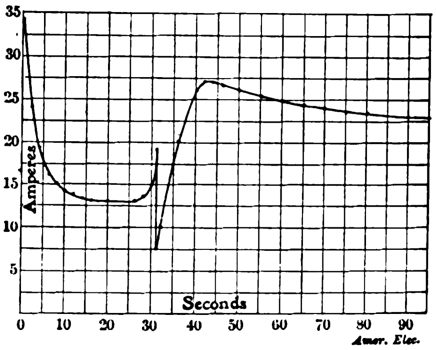

FIG. 5.—PERFORMANCE WHEN FIRST STARTED.

Fig. 3 shows the parts, except the globe, of a single-glower lamp, and Fig. 4, the holders for the six, two and three, and one-glower lamps.

It is of interest to note what takes place in the lamp during the time of lighting, and Fig. 5, which is taken from an excellent paper on this subject by Mr. A. J. Wurts, shows by means of a curve the current taken by a six-glower, 220-volt lamp during the lighting period. As the current was turned on, there was a sudden rush of nearly 3½ amperes through the heater, which, however, owing to the increase in resistance of the platinum wire was soon reduced to about 1.3 amperes. At the end of about 26 seconds, the first glower began to light; at the end of 30 seconds the second glower lighted and the heater was cut out; the current then dropped at once to ¾ ampere. The remaining glowers lighted rapidly from the heat given out by the first two, and at the end of 40 seconds all the glowers were lighted.

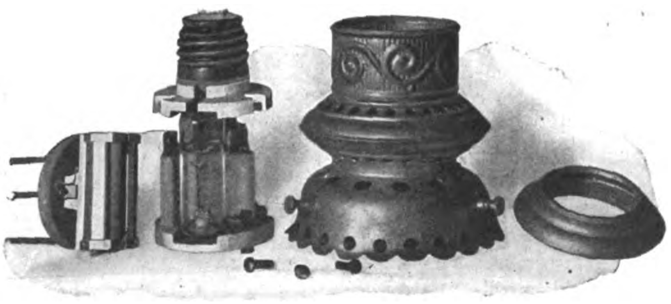

FIG. 3.—PARTS OF THE SINGLE-GLOWER LAMP.

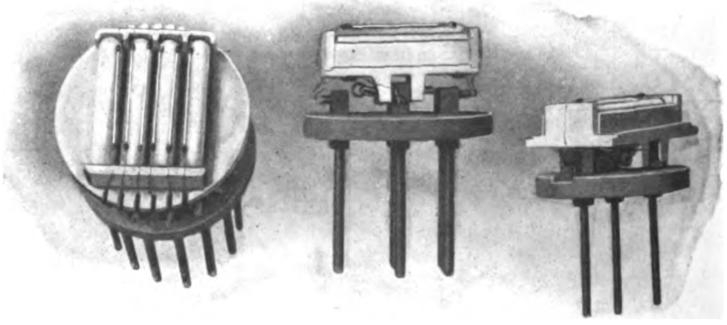

FIG. 4.—HOLDERS FOR THE SIX, TWO AND THREE, AND ONE-GLOWER LAMPS.

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[*] A current which flows first in one direction and then in the opposite direction; the reversals occurring many times per second.

Letters on Practical Subjects

Mr. Temple's Telephone Circuits.

To the Editor, American Electrician:—

The accompanying diagram (Fig. 1) is submitted as a solution of Mr. C. H. Temple's problem in telephone circuit connections which appeared in the April number of the AMERICAN ELECTRICIAN. The arrangement shown necessitates the use of a two-way switch and a double-pole push-button at station *B*, and two double-pole knife switches (or one double-throw, double-pole switch) and two push-buttons at station *A*. The condition of the circuits is normally as shown in the diagram. When central rings up station *A*, the current goes through station *B* by way of the upper of the three line wires, passes through station *B* by way of the upper of the three line wires, passes through the signaling bell differentially, and back to station *A* over the two lower line wires in parallel. Here one-half of the current passes through the resistance in shunt to the bell and the other half through the bell and thence back to the exchange. The object of the resistance coil in parallel with the bell is to make the current divide exactly equally between the two lower line wires so as to prevent the ringing of the bell at station *B*. In order to call up central from station *A*, the double-pole switch, *C*, is closed and the push button, *c*, depressed which prevents signaling to station *B*. In order to call up station *B*, the knife switch, *B*, is closed and the push-button, *b*, depressed; this connects the two stations through the two lower wires. When station *B* wishes to call up station *A*, the two-way switch is put on the contact, *a*, and the push-button, *M*, depressed. In order to call up the exchange from station *B*, the two-way switch is thrown to the contact, *c*, and the push-button, *M*, depressed. The two-way switch is left normally free from both contacts, and the switches *B* and *C* at station *A* are normally open.

Wilkinsburg, Pa. GLEN BASKERVILLE.

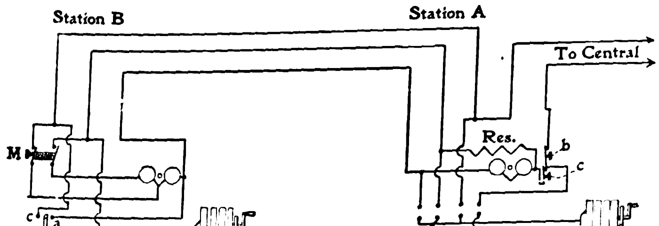

FIG. 1.—MR. BASKERVILLE'S SOLUTION.

To the Editor, American Electrician:—

I enclose herewith a diagram (Fig. 2) intended as a solution of Mr. Temple's problem in telephone connections, which was published in this department of the April number. The generators at stations *A* and *B* are intended to give a pulsating direct current, the direction of which depends upon the direction in which the handle is turned, and the bells are of the polarized selective type. In order to call up station *B* from station *A*, the push-button, *b*, is depressed and the generator handle turned so as to deliver a negative current to line wire No. 2. In order to call up central, the signaling is done without depressing the push-button, *b*, and the generator turned so as to send a positive current to the wire, *w*; the sneak current to station *B*, therefore, is of the wrong polarity, so that the bell there is not operated. Station *B* calls up Central by ringing without depressing the push-button, the handle of the generator being turned so as to deliver a negative current to the wire, *w*, which is in the wrong direction to ring the bell at station *A*. In order to call station *A*, the push-button, *a*, is depressed and the generator turned in such a direction as to deliver a positive current to the wire, *w*, which finds its return by way of the line wire No. 3. The condenser at station *A* prevents sufficient current from going to the central exchange to throw the drop there. The exchange calls up station *A* by throwing a negative current from the tip of the plug to line No. 1.

Probably better results would be obtained by using a two-magnet generator at station *B*, as indicated in the diagram, since this would be less likely to throw the drop at the exchange when calling up station *B*.

York, Pa. L. S. JENKINS.

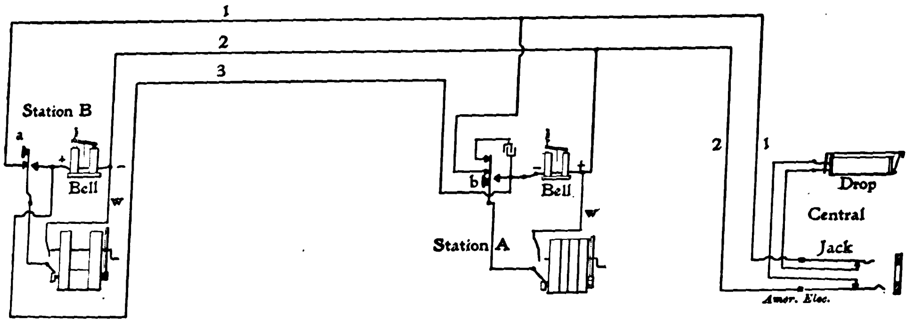

FIG. 2.—MR. JENKINS'S SOLUTION.

To the Editor, American Electrician:—

I herewith submit a solution of Mr. C. H. Temple's problem, which was published in the April number of the AMERICAN ELECTRICIAN (Fig. 3). As the diagram indicates, two condensers and an auxiliary call bell are used at station *A* in addition to the apparatus specified by Mr. Temple. This station is called up from the central exchange by means of the auxiliary bell, which is rung through condenser 1. Station *A* can call up station *B*, and station *B* can call up station *A*, without changing any of the connections by merely signaling in the usual manner. In order to call up the exchange from station *A*, the key is depressed and ringing current passes to the exchange through condenser 2. This is also true in calling up the central exchange from station *B*; in this case, however, the auxiliary bell at station *A* would also be rung if the condenser 1 were not interposed. The combined impedances of the two condensers are sufficient, however, to prevent the auxiliary bell from ringing when station *B* calls up the exchange.

New York. ROBERT KREMER.

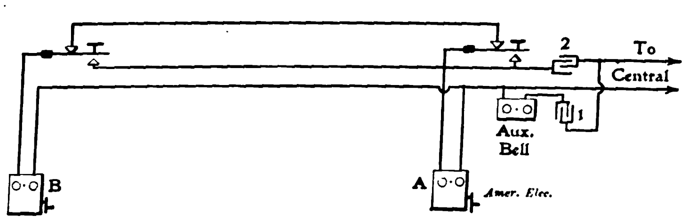

FIG. 3.—MR. KREMER'S SOLUTION.

◆◆◆

Single-Phase 60-Cycle Alternators in Parallel.

To the Editor, American Electrician:—

In the Questions and Answers department of the May issue, "E. A. W." asks if single-phase, 60-cycle alternators have ever been made to operate satisfactorily in parallel. It is rather surprising to me that any doubt should exist as to the ability to run such machines in parallel should it be desirable. When I took charge of the municipal plant at this place, there were two 60-cycle, single-phase machines belted to individual engines and operated singly on three primary circuits. The service on the circuits was such that when all three were fully loaded, one alternator was required to run through a considerable period with a heavy overload while the other carried less than its normal load, because one machine supplied two of the circuits. No attempt had been made to operate the machines in parallel, and in the face of much opposition and no encouragement the writer changed the switchboard connections so as to make parallel operation possible. Since January of this year the two machines have been operated in this way, with the results that the service is steadier, neither one of the machines is over-loaded and there has been extremely little trouble with regulation. Of course, factors which affect regulation have been watched more closely than before the circuits were consolidated.

Coffeyville, Kans. JUNIOR PARRISH.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Where can I find a description of a slide wire bridge that may be constructed by an amateur?
J. A. D.

Such a bridge is described in *Electrical Designs*, published by this paper.

If it should be desired to double the number of batteries specified for the automobile described in the January number, in order to increase the radius of action, would it be preferable to use motors of double the specified e.m.f., or put the batteries in parallel and use the motors as described?
L. D. N.

It would be preferable to use the batteries in parallel and not change the voltage of the motors.

Is hard-drawn copper wire of the same conductivity as soft-drawn wire? (2) Would it be good practice to make a span of No. 4 or No. 6 hard-drawn copper wire 1100 or 1200 feet long?
A. R. M.

No. The conductivity of hard-drawn wire is from 1 per cent to 2 per cent less than that of soft-drawn wire. (2) Decidedly not; if a long span is necessary to cross a stream, for example, it must be suspended at intervals from a span of steel cable above it.

How can a motor of given size and speed be made to give 50 per cent. more torque at the same speed without decreasing the kinetic energy of the armature?
H. J. R.

The torque cannot be increased at all without varying the speed if the motor is operating on a constant-potential circuit. In order to increase the torque, either the field strength or the armature current must be increased, and any increase in either one of these necessitates a reduction in speed.

How are laminated pole-pieces cast-welded in cast iron field-magnet yokes? (2) What are the advantages of plural two-path windings? (3) When plural windings are used, how many commutator segments must each brush cover?
G. E. M.

The magnet poles are built up and riveted together and then inserted in the sand mold in which the yoke ring is to be cast in such position that when the molten iron is poured into the mold it will surround the ends of the poles which are intended to be cast-welded in. (2) The only advantage is that the number of brushes may be reduced, as compared with a lap winding. Plural windings, as a rule, are not advisable, for the reason that they must be connected in parallel by the brush contact on the commutator, and this is not always of uniform resistance throughout the thickness of the brush. (3) Each brush must cover not less than ½ segment more than the number equal to the number of plural windings, and preferably one complete segment more. Thus, if there were three individual windings each brush should cover at least 3½ segments, and preferably 4.

Knowing any two of the values, volts, amperes and watts, how can the resistance of a circuit be determined?
J. C. H.

Representing the volts by E, amperes by I, watts by P and resistance by R, from the familiar Ohm's law $\frac{E}{R} = I$, may be deduced

$$\frac{E}{I} = R, \frac{E^2}{P} = R \text{ and } \frac{P}{I^2} = R.$$

What is meant by the pitch of a gear?
G. W. S.

A gear has two kinds of pitch-circular and diametral. The circular pitch is the distance from center to center of two adjacent teeth measured along the pitch circle. The diametral pitch is the number of teeth per inch of diameter, the diameter of the circle described by the pitch line being taken and not the external diameter of the gear. The pitch circles of two intermeshed gears, if scribed on the teeth, would just touch each other when the gears were properly meshed.

How can I ascertain what winding to use on a solenoid in order to adapt it for use on a circuit of different voltage than the one for which it is wound? (2) How can small storage cells be charged from a 110-volt direct-current circuit?
G. M.

Divide the cross-sectional area of the wire on the solenoid by the voltage for which it is to be wound and multiply the result by the voltage for which it was originally wound. This will give you the cross-sectional area of the wire that will have to be used. The new coil should be wound to exactly the same depth in inches as the old one. (2) If the cells are very small, say with a capacity of 4 or 5 amperes, they may be charged by connecting them in series with three or four 16-c.p. lamps, the lamps themselves being connected in parallel. The rated voltage of the lamps should be approximately the same as that of the circuit from which the batteries are charged.

Why is capacity measured in microfarads instead of farads? (2) What is the difference between self-induction and reactance? (3) What is meant by the "commutation frequency" of a direct-current machine? (4) Can an induction motor be operated as a generator?
J. H. B.

Because the farad is too large a unit for convenient use; no piece of apparatus or structure has ever been built with even 100 microfarads capacity. (2) Self-induction is a property and reactance is a phenomenon. For example, a coil of wire wound on an iron core has inductance, or self-induction, whether any current is passing or not, but it has no reactance until either an intermittent or an alternating current passes through it. Reactance is the product of inductance, the frequency of the current (alternating) and the constant 6.2832. (3) The "commutation frequency" is the number of times that the current would be reversed in the commutated coil in one second if the reversals were continued that length of time; in other words, the rate of reversal per second. (4) Yes, provided it be driven above synchronism and with the stator windings excited by alternating currents.

How can the field winding be determined for changing a series-wound railway motor into a shunt-wound machine?
R. A. L.

Run the motor as a series machine with full load and measure the voltage at the terminals of the whole field winding. Divide this voltage by the voltage of the circuit on which the motor is to be operated and multiply the result by the cross-section of the present field coil wire; the result will be the required cross-section of the shunt field wire. The new coils must be wound to occupy exactly the same space that is filled by the old ones.

What is the power factor of a direct-current motor? (2) If a ¼-h.p. single-phase motor has an efficiency of 60 per cent. and a power factor of 75 per cent., what efficiency and power factor should a ⅛-h.p. motor of the same design have?
C. H. H.

The term "power factor" is not applied to direct-current machines because every motor of this class has a power factor of unity. The term is used in connection with alternating-current motors because the apparent power taken by such motors is greater than the actual power; multiplying the apparent power by the power factor gives the actual power taken from the line. (2) There is not necessarily any definite ration between the two; the smaller machine would probably have an efficiency of from 40 to 50 per cent and a power factor of about 50 per cent, or possibly a little higher.

How is the multiplier 0.7249 obtained by which the equivalent of water evaporated per pound of combustible from and at 212° Fah. is multiplied in order to ascertain the water evaporated into steam at 70 pounds pressure, from 100° temperature, per pound of dry coal containing ⅙ refuse? (2) How is the multiplier 0.86898 obtained by which the equivalent of evaporation from and at 212° is multiplied in order to ascertain the water evaporated from 100° temperature into steam at 70 pounds pressure?
C. D. H.

The first multiplier is obtained from the second one. The evaporation of 30 pounds of water, having an initial temperature of 100°, into steam at 70 pounds gauge pressure is considered equivalent to evaporating 34½ pounds of water from and at 212°. Dividing the one by the other gives the factor 0.8696. The multiplier 0.7249 (more correctly 0.7247) is obtained by multiplying the first factor by $^5/_6$, since the proportion of combustible in the coal is $^5/_6$.

What is meant by a saturated solution? (2) What is the tertiary winding of an induction coil? (3) Could not the secondary winding, of the 6-in spark coil, described in *Electrical Designs*, be wound more conveniently and almost as cheaply by using single-cotton-covered magnet wire instead of bare wire and thread?
M. M. N.

A solution containing the greatest quantity of a given substance that the liquid will dissolve at the working temperature. (2) Any tertiary winding is the third of a series of three windings; we do not know of any induction coil built this way. The secondary winding is frequently divided up into two or more sections, but these are all connected in one circuit so that there is no tertiary winding in such a case. (3) The winding would be much more convenient and cheaper, but the insulation would be less effective and the results, therefore, less satisfactory.

AIR COMPRESSORS FOR RAILWAY BRAKES.

The accompanying illustrations show a line of direct-coupled air compressors developed by the General Electric Company for railway and general work of a comparatively light and intermittent character. The compressor consists of two main parts—the motor end and the compressor end. The motor is similar in design to the well-known General Electric box frame type of railway motors. The unsplit magnet frame has frame heads at each end which support the armature shaft bearings. At the compressor end, horizontal single-acting tandem cylinders are cast as a part of the frame head. The armature shaft bearing at this end is large in diameter, and the crank pin formed at the end of the shaft is located just inside the bearing diameter. By removing the four bolts which fasten the combined frame head and cylinders to the magnet frame, and taking off the retaining washer at the end of the crank pin, the compressor can be separated from the motor. On the removal of the compressor the armature can be taken from the magnet frame.

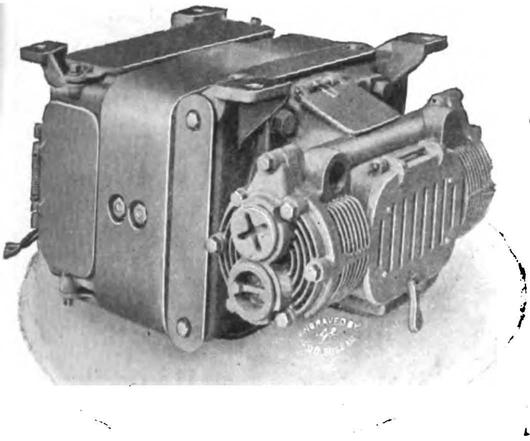

FIG. 1.—AIR COMPRESSOR, COMPRESSOR END.

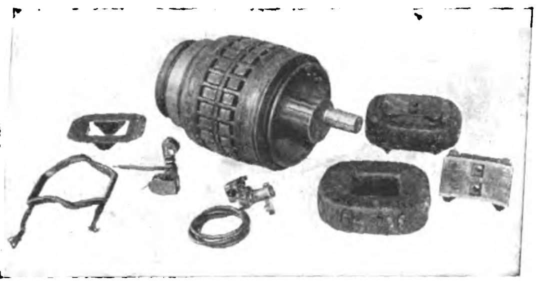

FIG. 2.—ARMATURE, FIELD COILS AND BRUSH-HOLDERS

Working in the tandem cylinders is a single double-ended piston actuated by a single connecting rod which connects the crank pin to a wrist pin located at one end just back of the piston head. By removing one of the cylinder heads, the piston can be drawn out. The whole construction is exceedingly simple, and aside from the contact between the piston and the cylinders, there are but four bearings. Compressors are furnished with lugs cast on top of the magnet frame for attaching to the underside of the car framing or with feet for setting up on a floor.

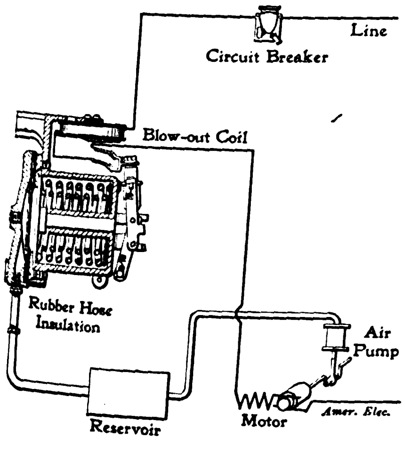

FIG. 3.—CONNECTIONS TO AIR COMPRESSOR GOVERNOR.

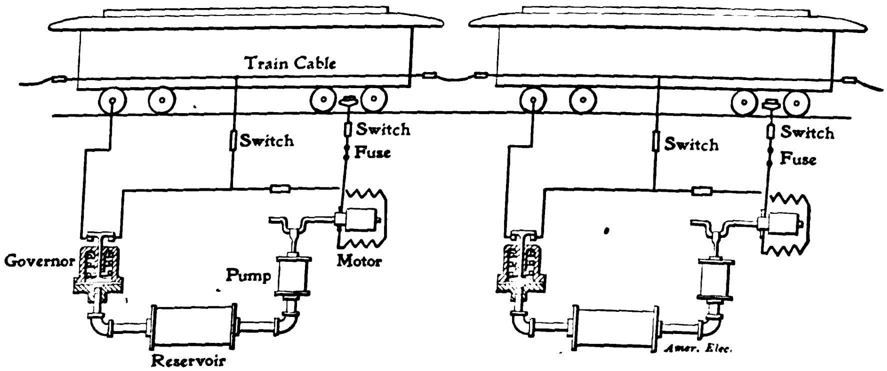

FIG. 4.—CAR AND TRAIN CONNECTIONS.

The magnet frame is cast steel, unsplit, and cubical in shape with well rounded corners and inwardly projecting poles. There are a number of openings fitted with malleable iron covers which permit of easy inspection and access to the commutator and brush-holders. With covers on, the motor is completely enclosed. Under service conditions which will permit of it, the covers can be left for ventilation if desired. There are large openings in the ends of the frame through which the armature can be easily put in place. The openings are filled with the frame heads which support the armature crank shaft bearings.

The frame heads project well within the armature, this construction permitting long and liberal bearings, without sacrificing the compactness of the compressor. At the commutator end of the motor, the frame head is accurately bored to receive a sleeve bearing lining. A large well, fitted with a spring-hinged cover, is cored in the head to receive oil to lubricate the bearing. The frame head at the compressor end is cast in a single piece with the compressor cylinders. The head carries a large lining for the shaft bearing and has provisions for lubrication similar to that on the commutator end.

The two compressor cylinders are cast in a single piece with the compressor end frame head which carries the shaft bearing and oil well. The exterior of the cylinders is well ribbed to radiate the heat generated during compression, and the interior surfaces are accurately bored in alignment. The extension of the casting between the cylinders forms an enclosed chamber hollowed at the bottom to receive a quantity of oil for the lubrication of the cylinders and the connecting rod bearings. The parts may be inspected through an opening in the front, which is provided with a hinged cover.

Each cylinder head contains two bored chambers which contain the valves. A large plug screwed against a copper gasket closes each chamber and allows easy removal of the valves. Liberal passages are cored in the casting around the outlet valve, connection being made with an air passage between the cylinders.

The trunk piston consists of a single casting with a head at each end, and hollowed in the central portion, leaving strong ribbed sections. Within the space between the heads, the connecting rod and crank pin play, forming a very compact construction. The wrist pin on which the connectting rod pivots is located just back of one of the piston heads. The pistons are accurately turned and grooved for cast-iron packing rings with lapped joints.

The valves are composed of small, light disks, playing noiselessly, with small clearances and minimum leakage. They operate on accurately machined seats within a steel casing. There are no springs or complicated parts to deteriorate under the high temperature of compression. The inlet and outlet valves are the same in general design, the seats being merely reversed in position.

Aside from the contact between the pistons and the cylinders, there are but four bearings—two armature shaft bearings and two connecting rod bearings. The shaft bearings consist of brass sleeve linings, cut away on the sides to allow oily waste in the oil wells to press directly against the shaft. The slow speed of the armature and the liberal dimensions of the parts are said to insure a long life for the bearings. Oil deflectors on the shaft prevent oil from getting into the interior of the motor. The overflow is caught in channels leading to drip cups cored in the castings beneath the bearings.

An effective method of lubricating the cylinders and connecting rod bearings is furnished by a finger, fastened to the end of the crank pin, which in rotating through the oil at the bottom of the compressor chamber distributes it over the bearing surfaces.

Fig. 1 is a view of a compressor from the compressor end. Fig. 3 shows the connections of an air compressor governor, and Fig. 4 the car and train connections.

New Apparatus and Appliances

S. K. C. CIRCUIT BREAKER.

The S. K. C. circuit breaker illustrated herewith embodies a number of features which distinguish it from other similar devices. Prominent among these is the independent opening action, which makes it impossible to close the breaker on an overload. The closing toggle is automatically disconnected from the operating handle, and the jaws open, regardless of the pull which is being applied to the handle, the instant that sufficient current passes through the carbon contacts to operate the tripping device. Thus the dangers which result from circuit breakers being forced in upon an overload are eliminated. To trip by hand, the closing action is simply reversed; *i.e.*, the operating handle is pushed up. By an ingenious arrangement of the iron core and the magnet coil, two turns are made around the core in a limited space. The iron core consists of two parts, one fixed and the other movable, which are so arranged as to have but one air gap in the magnetic circuit. The movable portion of the core operates the tripping device, as can be seen in Fig. 4. The main contact blocks are bridged by a sectional laminated copper arm, each section of which may be adjusted separately to secure good contacts, and attention is called to the ease with which this adjustment is said to be accomplished. The main contact blocks are fastened to the marble base independently of the studs, which may be of any length, to suit the switchboard construction. The arrangement of the arc-rupturing carbons is decidedly unique. The carbon blocks have a certain amount of spring-actuated movement, and come together with a sliding action, as can be seen from the illustration, which lessens any tendency to break. The surfaces are large and the rubbing action taking place between them when the breaker is opened or closed ensures clean contacts. As will be seen from the illustrations, Figs. 1 and 3, a long break between the carbons is secured with a comparatively short movement of the main contact arm, and arcing occurs at a safe distance from all metal parts. In addition to the shunt circuit through the carbon contacts, there is an auxiliary shunt composed of smaller copper arms, which remain in contact momentarily after the main contacts are opened, thus further protecting the latter. Both the main and the auxiliary contact arms are clearly shown in Fig. 1. In the "S. K. C." circuit breaker the setting device consists of a rack having a projecting bracket upon which rests the movable section of the magnetic core, and a pinion, engaging therewith, at the end of a short shaft which carries on its outer end a helical spring, a notched dial and an insulated knob, the arrangement of these parts being clearly shown in Fig. 4. It will be evident that by rotating the dial, the air gap in the tripping magnet may be varied and a fine adjustment secured. The operation of setting consists simply of pushing the knob, so that the dial is free from the index pin holding it secure, and rotating it until the figure indicating the desired tripping point is opposite the index pin. On releasing the knob, the dial springs out and locks itself in the pin. The large diameter of the setting dial gives, on its periphery, a scale approximate-

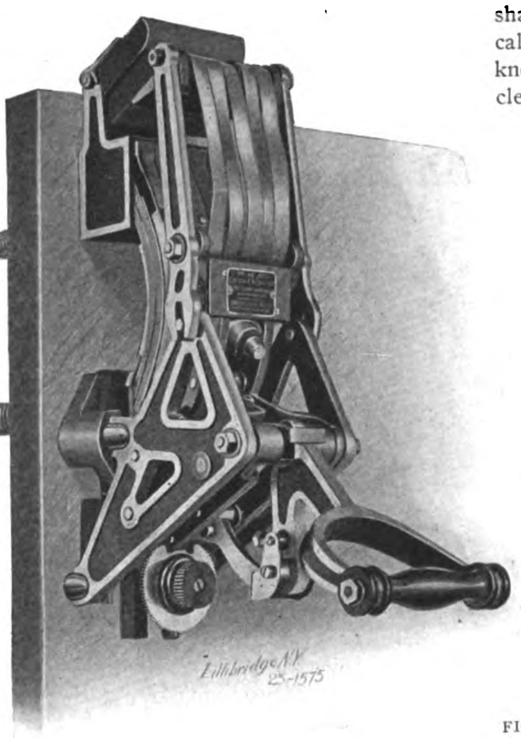

FIG. 2.—CIRCUIT-BREAKER CLOSED.

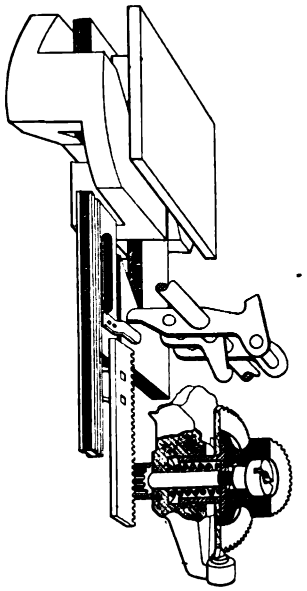

FIG. 4.—ARRANGEMENT OF MAGNETIC COIL AND CORE AND SETTING DEVICE.

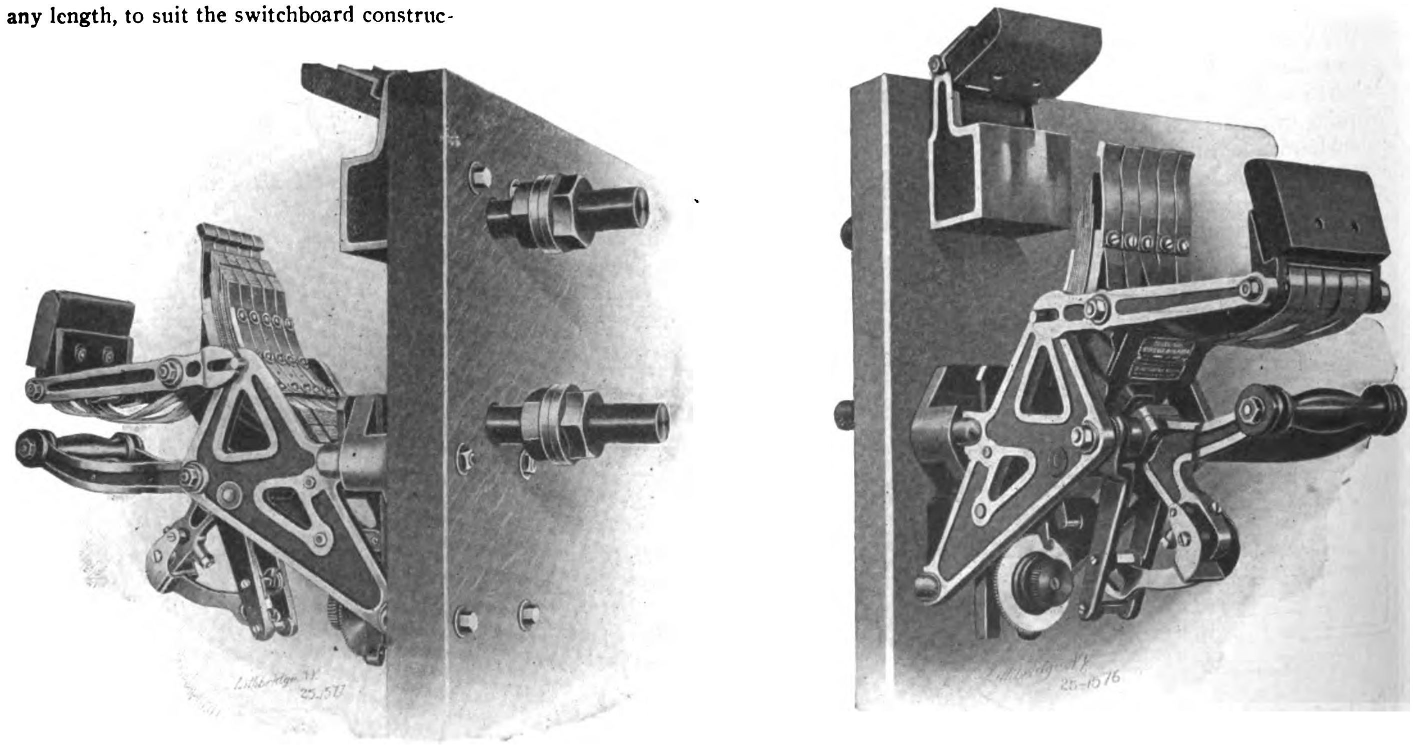

FIG. 1.—TWO VIEWS OF S. K. C. CIRCUIT-BREAKER OPEN.—FIG. 3.

ly 9 inches long. These circuit breakers operate on either direct or alternating current circuits, and are made in capacities from 200 to 3,000 amperes. They are made by the Stanley Electric Manufacturing Company, of Pittsfield, Mass.

ELECTRIC STORAGE BATTERY LOCOMOTIVE.

The C. W. Hunt Company, of West New Brighton, New York, has brought out the electric locomotive shown by Fig. 5 herewith, the energy to drive it being supplied by a storage battery. The locomotive is built for the standard 4-ft. 8½-in. gauge, and fitted with standard couplings, making it suitable for use with any ordinary railroad car, and on any standard railroad track. The length over the bumpers is 21 ft. 4 in., and the height from the rail head to the top of the cab is 12 ft. 1 in. The wheel base is 7 ft. 6 in., and permits the operation of the locomotive over a comparatively smaller turntable. It weighs about twenty tons, and runs at a speed of from two to four miles per hour on level track. As will be seen from the illustration, the locomotive is "double-ended," the cab being located directly in the center. This makes a very desirable arrangement for switching work, which calls for operation in both directions with equal facility. The batteries are contained in the sloping compartments at either end. This disposition distributes the weight evenly on the four wheels, and, as each of these is a driver, the entire weight of the locomotive is usefully employed in traction. The wheels and axles are driven from the gear cases in the cab by means of Renold silent chains suitably enclosed. These chains are the only portion of the driving gear situated below the car body, the motors and gear cases being mounted in the cab where they are readily accessible, and always under the immediate notice of the operator. The battery elements are mounted in tanks of extra depth to prevent the electrolyte from splashing over the top. In mounting the battery special attention has been paid to protecting it against injury due to the shocks to which the locomotive is exposed in switching. There are two motors, specially wound, for the service. By connecting the two motors in series or parallel, and by varying the arrangement of the fields, an efficient speed control is obtained without wasting any of the energy of the battery by passing it through a resistance. The controller is of the standard vehicle type, and has two levers which control every desired motion of the locomotive. The reversing lever is set to point in the direction in which the locomotive is to move, and the second lever controls the speed. These levers are mechanically interlocked, as in the case of a trolley car controller, so that the motors can only be reversed when the speed lever is in the off position. The locomotive may be run with the controller in any notch, there being no transition point on which a careless operator might leave his lever and burn out the apparatus. As already mentioned, the speed-reducing gearing is located in the cab, instead of being beneath the car body. All the gears are machine cut, and run in a bath of oil, in fully enclosed gear cases of the C. W. Hunt Company's standard type. The same company's regular flexible and insulated coupling is used for connecting the motor to the gear case. There is a separate gear case for each of the two motors, the driving gear consisting of two parts, which are exact duplicates of each other. In an emergency, one motor could be cut out entirely, and the locomotive operated by the remaining motor, but with a reduction of hauling capacity. The speed reduction of the gear case is said to be so proportioned to the safe discharge rate of the batteries, the safe capacity of the motor and the weight of the locomotive, that neither the batteries nor the motors can be dangerously overloaded. The driving axles are made to standard dimensions, and run in "Hunt" patent roller bearings. The wheels are shrunk in place, and have chilled treads and flanges of M. C. B. standard size and shape. A powerful brake is conveniently located in the cab. An alarm gong is also provided. Experience has shown that in light switching service, the batteries can be recharged at various times during the day while the locomotive is waiting between hauls. For heavier service, it may be necessary to charge during the noon hour or after working hours in the evening. The battery is automatically protected during charging by well-known safety appliances, which open the circuit if the current is excessive, and also when it drops so low as to indicate that the battery is fully charged.

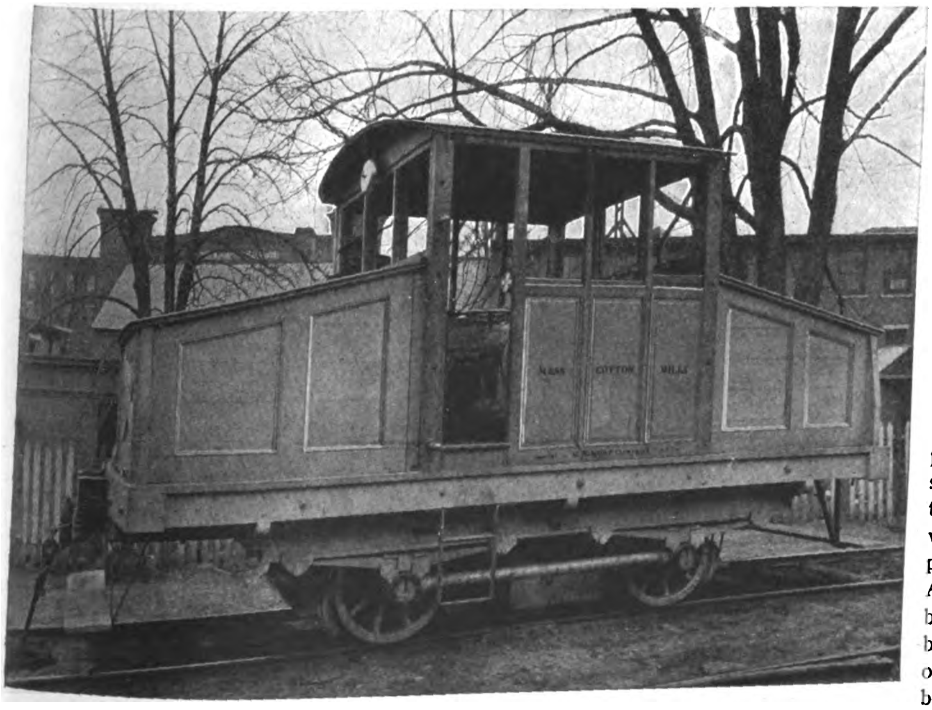

FIG. 5.—20-TON ELECTRIC STORAGE BATTERY LOCOMOTIVE.

BITUMINIZED FIBRE CONDUIT.

Fig. 6 herewith shows partial lengths of bituminized fibre conduit made by the American Conduit Company, of Philadelphia, Pa. The conduit is made from material of a bituminous nature and is, therefore, non-corrosive. The fibre entering into its construction is saturated and coated with the bituminous compound so as to practically lose its identity except for the stiffening and strengthening qualities for which it is used. A commendable feature of the conduit is its lightness and the ease and rapidity with which it is put down. As shown, the conduit has a male and female slip joint which is turned true in a lathe. The joint is said to be self aligning, making it possible to easily and rapidly slip together in the trench unit after unit of the conduit ready for the grouting. No wrapping with burlap or other material is required and no trowel work is said to be necessary. A pot of liquid compound is kept conveniently at hand and into this the workman lightly dips the end of each unit as he passes it into the trench. When the work is completed each duct is said to be practically one continuous tube. The absence of any abrasive or gritty surface in the conduit adds to the ease and rapidity with which cables can be drawn in and also permits of manholes being widely separated. An idea of the lightness of the conduit may be obtained, and the ease with which it can be handled when it is stated that 20,000 ft. of the 3-in. size can be loaded in a standard box car and almost twice this amount in a furniture car. Two men can handle a crate containing 140 ft. of 3-in. conduit. The conduit is made in 7-ft. lengths and can be sawed in two by an ordinary hand saw. Hand tools can be obtained for turning new joints on sawed ends.

FIG. 6.—BITUMINIZED FIBRE CONDUIT.

KRAUSHAAR'S UNIVERSAL DUSTER.

Fig. 7 herewith illustrates the Kraushaar cylinder dust bellows made by P. Peiffer, of Newark, N. J. The duster is intended for cleaning dynamos, motors, telephone instruments, switchboards, etc. There are no metal mountings, the nozzle as well as the body being made of wood so as to preclude any danger from short circuits. The bellows is made in five sizes ranging in length from 20 to 32¼ ins., and in weight from 10½ to 32½ ozs.

Universal Duster.

FIG. 7.—KRAUSHAAR'S UNIVERSAL DUSTER.

HORNSBY-AKROYD OIL ENGINE.

The accompanying illustration shows a new type of the Hornsby-Akroyd Patent Safety Oil Engine, which the makers, The De La Vergne Refrigerating Machine Company, of New York, have recently designed and put on the market. The illustration shows a 15-h.p. engine direct-connected to a multipolar dynamo. The engine runs at a speed of 450 r.p.m., and being of the two-cylinder type, an explosion at every revolution is obtained. The crank shaft is a solid steel forging, the crank pins being placed in line. The fuel is supplied to the vaporizers by two separate oil supply pumps, and, accordingly, the engine, if desired, can be operated as a single-cylinder engine. The regulation of speed, the most important feature of an engine of this class, is stated to be 2 per cent.

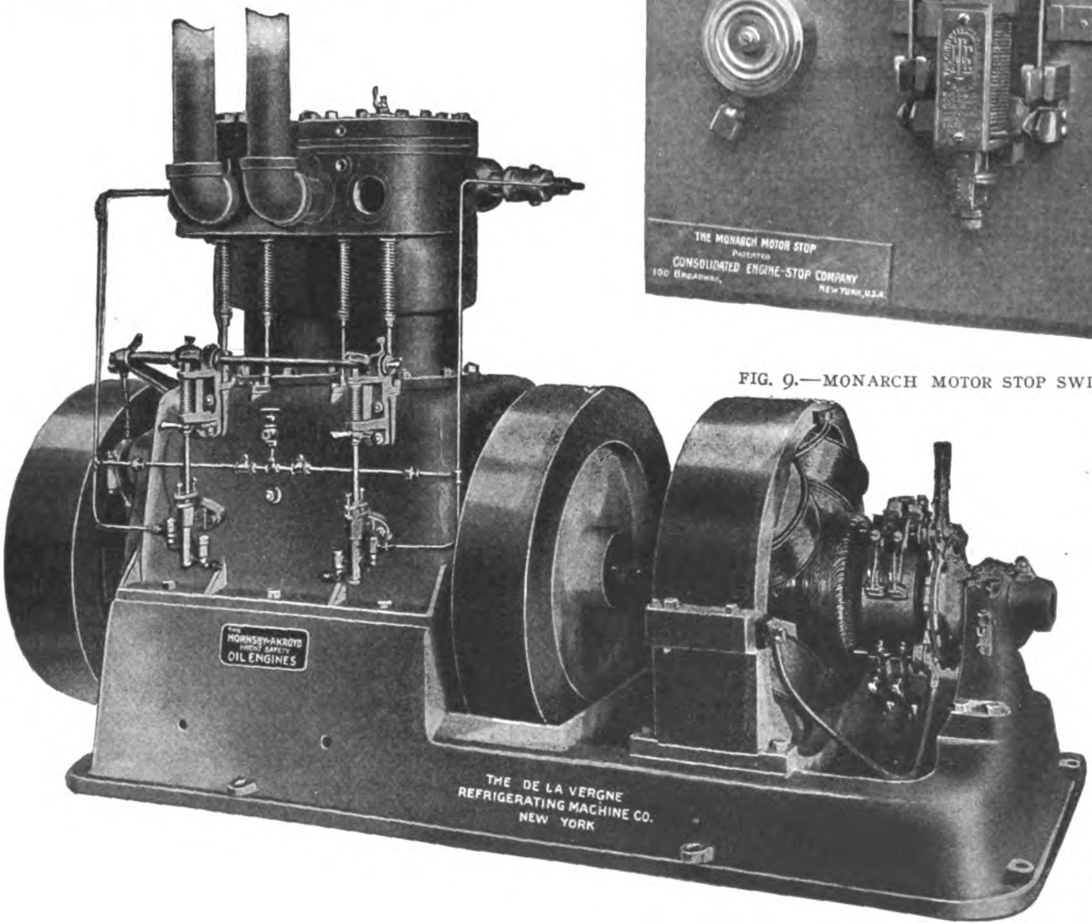
THE HORNSBY-AKROYD PATENT SAFETY OIL ENGINES
THE DE LA VERGNE REFRIGERATING MACHINE CO. NEW YORK

FIG. 8.—HORNSBY-AKROYD OIL ENGINE.

The engine operates on "Beau-de-Rochas" or four-cycle principle. Air is drawn into the cylinder through a positively operated air valve, and kerosene oil is simultaneously pumped into the vaporizer attached to the cylinder, which communicates with it by a narrow neck. These operations are performed during the outstroke of the piston. When the piston returns, it forces the air into the vaporizer, in which chamber it combines with the hot oil vapor, and ignition and combustion take place. The governor, which is placed in the fly-wheel of the engine is the Rites patent governor. This device directly operates the oil supply pump, and the length of stroke of the pump is automatically varied according to the load which the engine is carrying.

MONARCH MOTOR STOP.

The increased use of the electric motor for power purposes has resulted in the production of a quick-stopping device for these machines in case of accident. This stop brought out by the Consolidated Engine Stop Company, of New York City, places the motor or motor-driven machine under control from any number of places in the factory. Snap switches are distributed about the works and one turn of the switch operates on a separate battery system to throw the main switch on the board. A bell in the office or engine room immediately rings so as to notify the person in charge that the current has been switched off. The board which is shown by Fig. 9 is made of marble or slate and carries besides the main switch apparatus for testing for low battery power or short circuits. The device, which may be installed to protect the whole line or a single motor, is said to stop a machine under load in from two to five seconds. It is applicable to any size of motor.

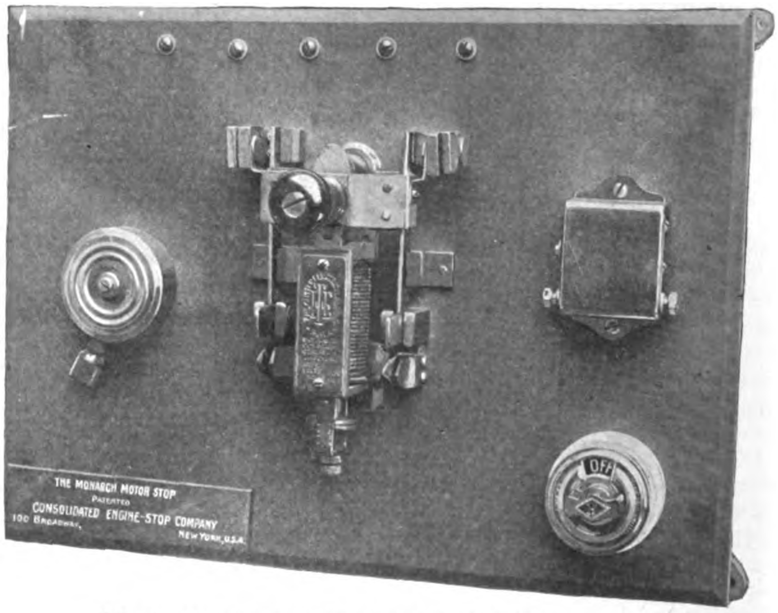
THE MONARCH MOTOR STOP
PATENTED
CONSOLIDATED ENGINE-STOP COMPANY
100 BROADWAY, NEW YORK, U.S.A.
OFF

FIG. 9.—MONARCH MOTOR STOP SWITCHBOARD.

ENCLOSED ARC LAMP.

The General Incandescent Arc Light Company, of New York City, has made improvements in their enclosed arc lamps, which, it is claimed, cause them to possess advantages over other constant-potential, direct-current arc lamps. The clutch is entirely insulated from the mechanism and, therefore, no current can sneak over the working joints of the clutch, clutch links, feed lever and dash-pot. The adjustable regulating resistance is mounted on several porcelain units. The required number of resistance units are fastened by screws to a light circular casting which is attached to the top casting of the lamp. These resistance units are connected by screw clamps, and the beginning and end leads are connected to the proper binding posts under the top casting. This form of resistance permits operating and maintenance economy. Damage occurring in any part of the resistance wire does not disable the entire coil, but only a quarter or sixth part is affected, and such damaged part or unit can be replaced by removing three screws and inserting a new interchangeable unit. The whole resistance can be removed from the lamp by unscrewing the two supporting and two clamping screws. The adjustable resistance clamp is a much more important factor in a constant-potential lamp than is generally understood. A well-designed clamp must always make a good elastic contact with the wire, and it should preferably cover a considerable wire surface, so as to prevent the wire from rusting and also to preserve a perfect contact and allow the expansion and contraction of supporting porcelains under all possible conditions. Poorly designed adjustable contacts will cause much trouble, allowing the arc adjustment of the lamp to change, due to increase of resistance in contact between the clamp and wire. It frequently happens, due to lack of appreciation of the importance of the above, that lamps are hung and allowed to operate year in and year out until the arc voltage gets so low that the lamp burns out or the customer complains. The increased resistance and excessive heating at the point of contact between the clamp and resistance wire will, moreover, cause the wire to get so brittle and weak that it is liable to break without warning. Such troubles are claimed to be impossible with the new style broad contact clamp manufactured by the General Incandescent Arc Light Company.

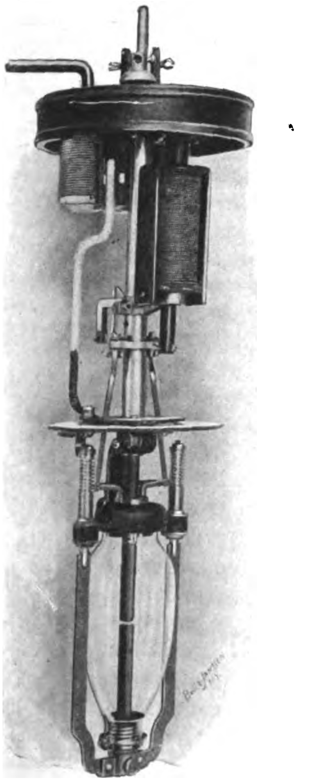

FIG. 10.—G. I. ENCLOSED ARC LAMP.

The solenoid (or magnet coil) construction differs from the types used on previous L-I and the first L-II lamps (Form A) in that the coil is form-wound and is removable from the dash-pot plunger with its tube from the magnet coil. In consequence of this change, the new magnet coil can be placed on the lamp without the dash-pot and graphite plunger. This form-wound magnet coil is furnished without brass heads or tube, which are unnecessary in the form B lamp. The dash-pot tube and plunger can be furnished separately. The bracket, which supports the mechanism and magnet coil in the L-II (Form B) lamp, is made heavy and strong and is, therefore, not liable to bend during transit.

INSTALLATION OF MODERN LIGHTING TRANSFORMER.

In the endeavor to eliminate the difficulties which linemen meet in installing transformers of moderate sizes, the Fort Wayne (Ind.) Electric Works has studied the requirements of practice with a view to overcoming them. In bringing out the lead from the case, the cables are passed through very heavy porcelain bushings. The insulation of these bushings is in excess of what is required for the actual service, but they are made extra heavy in order that any chance blows will not easily break the porcelain bushings, thus encouraging grounds from the primary circuits. The primary coils of the standard transformer are all arranged so as to be connected in multiple or in series. This connection is made by changing links fastened to a porcelain block inside of the transformer case. As only two leads are required from the primary at any one time, this method of connecting the primary coils in series or in multiple is claimed to be preferable to a connection outside of the box. The multiple and series connections of the leads from the secondary side of the transformer are made outside of the box in order to facilitate making connections for three-wire service when required.

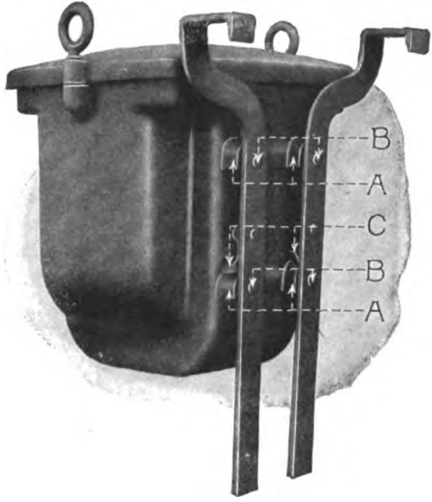

FIG. 11.—CAM-LOCKING SUSPENSION HOOK.

The subject of suspension hooks has been given careful attention; the idea being to produce a hook that will be as strong as possible, and at the same time will allow the transformer to be installed or taken out of service at any time with ease. It frequently happens that a station man desires to change transformers, substituting for the one in service a larger one on the same hooks to operate more efficiently an increased number of lights in that vicinity. If this can be done without removing the hooks from the pole a saving can be made in time and labor in changing transformers. It will be noted from Fig. 11 that the studs, *B*, seated in the pockets, *A*, cast on the transformer boxes are solidly riveted into heavy wrought iron straps. A cast iron cam, *C*, is so arranged as to lock the studs into these pockets. This obviates the disadvantage which pertains to those hooks using bolts to fasten the strap to the box, in that the hook will never be rusted to the box. In case the cast iron cam should stick in place a blow from a hammer will easily throw it to one side, and as the riveted studs which engage the pockets are contained loosely there is no opportunity for these to rust to the transformer box.

RESISTANCE REQUIRED IN SERIES WITH AN INCANDESCENT LAMP TO PRODUCE A GIVEN CANDLE-POWER.

The accompanying chart should be a most useful one to those concerned with the operation of theatre dimmers, since it enables one to predetermine accurately the amount of resistance necessary for insertion in series with an incandescent lamp or a group of lamps in order to reduce the candle-power to any desired point. The horizontal scale applies to the resistance in series with the lamp or lamps taken as a percentage of the lamp resistance itself, and the vertical scale, of course, is calibrated directly in candle-powers. For example, if a resistance equal to 10 per cent of the resistance of the lamp is used, the illumination of a 16-c.p. lamp will be reduced to 9.4 candles. With a resistance equal to 20 per cent of the lamp resistance, the candle-power will be reduced to 5.2, and so on. As intimated above, the drawing applies just as well to a group of lamps as to a single lamp, the dead resistance being then figured as percentage of the resistance of the whole group of lamps. This chart was prepared for the Wirt Electric Company by Prof. J. W. Langley, of the Case School of Applied Science, Cleveland, and is based on an efficiency of 3.1 watts per candle.

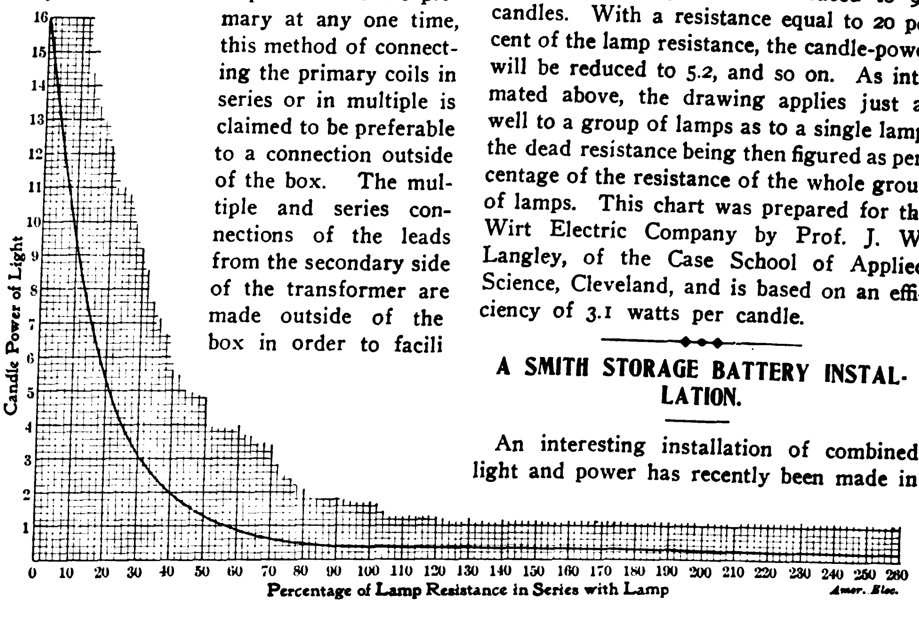

FIG. I.—INCANDESCENT LAMP-RESISTANCE CURVE.

A SMITH STORAGE BATTERY INSTALLATION.

An interesting installation of combined light and power has recently been made in the new Hotel Carlton at the corner of Boylston and Heminway Streets, Boston, one of the features of which is a large installation of the Smith storage battery, as shown in the accompanying illustration, consisting of 57 trays, and having a capacity of 800 ampere-hours at 114 volts. This type of battery was brought out by the Smith Storage Battery Company, of Binghamton, N. Y., and is a radical departure from the beaten path in battery manufacture, although it involves no new principles, being of the ordinary lead-sulphuric acid type. Jars are dispensed with altogether, the lead plates themselves holding the electrolyte. The gridded plates are formed into oblong trays, any number of which may be nested on top of each other; separators of perforated seats of hard rubber, or other suitable acid-proof material, keep the trays from electrical contact with each other. There is sufficient space between the trays to hold the electrolyte, which is in contact with the bottom of the tray above it and the inside of the one which holds it; the chemical action takes place, therefore, between the upper side of one plate and the under side of the one above it. In preparing the plates, the under side of each tray is chemically reduced to lead oxide, and the upper side to peroxide of lead, so that the upper side of each tray is the positive and the under side the negative electrode of what in an ordinary battery would be a single two-plate cell. By adding another tray to the nest the potential is increased by 2 volts, since the successive trays are connected in series. The upper side of the upper tray, and the under side of the bottom tray are plain and inactive; the voltage of any battery will therefore be two less than twice the number of trays; thus, a battery of eleven trays will give 20 volts. In ordinary work there is no connection between the plates of the battery, except the electrolyte. The negative terminal is connected to the top of the upper tray and the positive terminal to the top of the bottom tray. However, it is possible to obtain any combination of series-multiple or multiple-series connections by attaching terminals to as many trays as desired and cutting in or out additional trays as the service demands. The arrangement of trays obviates a trouble frequently met with in storage batteries; that is, the deposit, in the bottoms of the jars, of active material which is liable to cause a short-circuit between the plates. In this battery the positive plate, the one from which such deposits usually come, is the upper side of the tray, and hence, all particles which may become free will lie where they are, without danger of causing a short-circuit.

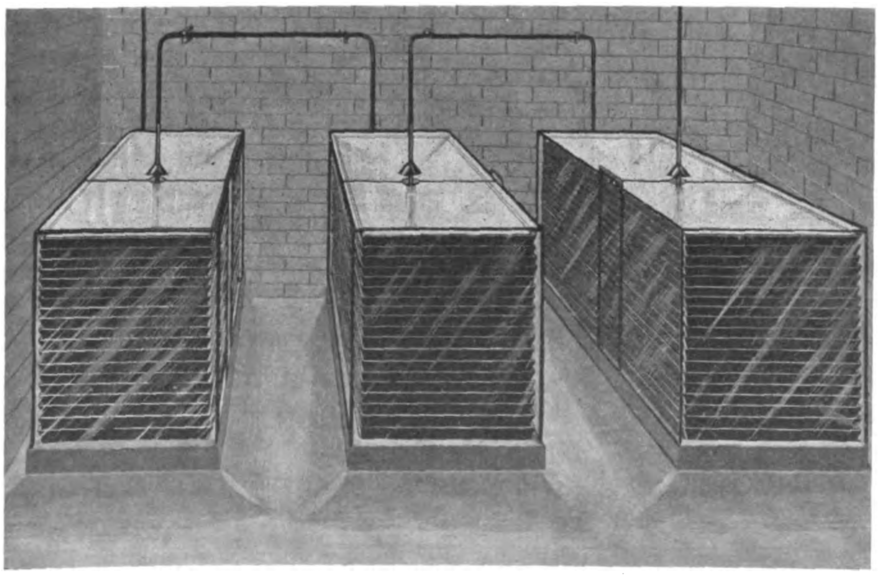

FIG. I.—SMITH STORAGE BATTERY.

NEW BOOKS.

Dies: Their Construction and Use for Working Sheet Metals. By Joseph V. Woodworth. New York: Norman W. Henley & Co. Cloth; 384 pages, 8 ins. x 9 ins.; 505 illustrations. Price, $3.

This is a most useful book to those who have to do with the construction or use of punches and dies for stamping shapes in sheet metal. The author discusses his subject from a practical standpoint and in a very thorough manner, covering methods of annealing and tempering, the use of files and similar allied topics, with as much care and accuracy as the main subject of building and using dies.

Conductors for Electrical Distribution. By F. A. C. Perrine. New York: D. Van Nostrand Company. Cloth; 287 pages, 6 ins. x 9 ins.; illustrated; 5 charts. Price, $3.50.

This is *not* a "wiring book" in the ordinary sense of that term. On the contrary, it is a very complete discussion of electrical conductors, their manufacture and insulation, their arrangement in cable form, the determination of wire sizes for given circuits and the construction of both overhead and underground lines. The portion of the book devoted to calculation of circuit wires is the least meritorious, being a more or less perfunctory summary of the methods hitherto brought out for determining wire sizes. The charts are reproductions of those of Badt, Starke and Hering. The remainder of the book is excellent, containing exactly the class and quantity of information necessary to complete the subject when taken in conjunction with a good wiring hand-book.

The Universal Electrical Directory. (Berly's.) London: H. Alabaster, Gatehouse & Co. Cloth; 1413 pages, 6 ins. x 9½ ins. Price, 10 shillings in Great Britain; 13 shillings in other countries.

This is the twenty-second annual edition of the well-known red-back directory published by the proprietors of the London *Electrical Review*, and fully sustains the reputation established by preceding editions. It is but natural to judge a publication of this class by the character of that portion relating to one's own country and locality, and as that portion of the present book is astonishingly complete and relatively accurate, we conclude that the remainder is equally commendable. The book has been enlarged by about 50 pages since the last previous edition.

The Electrician Electrical Trades Directory. London: The Electrician Printing & Publishing Company. Two volumes. Cloth; 1460 pages, 6 ins. x 9½ ins. Price, 12½ shillings.

The growth of this familiar "blue book" has been such as to cause the publishers to divide it into two volumes, Part I being the British section and Part II containing the foreign and biographical material. There is also a very complete set of tables giving statistics of electric light and power plants and maps of important distribution and railway systems in Great Britain. These are contained in a rather cheap and flimsy pocket on the outside of the cover of Part II. Aside from this pocket—which is more properly a mere strap from end to end of the book, being open on both side edges—the directory is in accord with the excellent character of the previous editions. The work is not merely a directory; it contains a great deal of information relative to expiring patents (British), legislative acts applying to electrical undertakings, British wiring rules, etc.

OBITUARY.

JOHN FORNEY STAUFFER, president of the Geo. C. Towle Manufacturing Company, Lancaster, Pa., died recently. Mr. Staffer was born in Penn township in 1845, but his ancestors came from Switzerland in the 18th century. Mr. Stauffer, previous to going into the electrical business, was a contractor for railroad, water-works and similar construction. The business of the Towle Company will be continued under the same general management as heretofore.

PERSONAL.

MR. G. W. SCOTT, a consulting engineer well known in the West, has removed his offices to 1301 Security Building, Chicago.

MR. ANGUS S. HIBBARD, general manager of the Chicago Telephone Company, has been elected second vice-president of the company.

MR. F. D. LESLIE, formerly half owner of *The Engineer*, of Cleveland, has sold his interest in that paper and bought an interest in *The Engineer's Review*.

MR. FRANK J. SPRAGUE, the well-known electric railway pioneer, has been awarded the Elliot Cresson medal by The Franklin Institute for his multiple unit system of electric traction.

MR. GEORGE F. SCHMINKE, formerly with the Sachs Electric Company, St. Louis, has left that company to accept a position with the Western Electrical Supply Company, St. Louis.

GEN. E. S. GREELEY, for many years prominent in the electrical supply trade as president of The E. S. Greeley & Co., and now one of New Haven's prominent bank presidents, was recently elected president general of the National Society of Sons of the American Revolution.

MR. F. D. SAYLOR, for some time past traveling representative of the Commercial Electric Supply Company, St. Louis, has severed his connection with that company and announces his intention to establish an electrical supply house at Pittsburg.

MR. J. L. PUTNAM, general manager of the Clark Automatic Switchboard Company, Providence, R. I., returned recently from an extensive business trip through the West. Mr. Putnam closed a number of important contracts and is very much gratified by the promising outlook.

MR. J. F. CALDERWOOD, who a year or so ago came from St. Paul to Brooklyn as assistant to President Greatsinger of the Brooklyn Rapid Transit Company, has just been elected third vice-president of that company and has also been appointed general manager of the system by President Winter.

MR. EDWARD HUBER has withdrawn from the firm of McCrosky & Huber, Cincinnati, manufacturers of adjustable reamers, to accept the position of assistant superintendent of the Bullock Electric Manufacturing Company's shops. Mr. Huber will have charge of the night force of the Bullock establishment.

MR. RAY D. LILLIBRIDGE, the well-known advertising manager for the Stanley Electric Manufacturing Company, the Link-Belt Engineering Company, and other priminent corporations, has again outgrown his quarters and been compelled to move. His new offices are on the fourteenth floor at 170 Broadway, New York, where he has much more space.

MR. GEORGE T. HANCHETT, the well-known consulting engineer, has removed his offices from 116 Nassau Street, New York, to the Engineering Building, 114 Liberty Street. Mr. Hanchett makes a specialty of electrical tests and reports on materials, apparatus and installations; he also devotes particular attention to electrical and mechanical machine design.

MR. MORTIMER J. HIGLEY has resigned the superintendency of the lighting department of the Burlington (Ia.) Railway & Light Company to accept the management of the Belvidere (Ill.) Gas & Electric Company, Belvidere. Mr. Higley is prominent in the affairs of the Iowa Electrical Association and is well known as one of the most progressive central station men in that state.

MR. WILLIAM KENT, the well-known consulting engineer, and associate editor of the *Engineering News*, has been appointed Dean of the L. C. Smith College of Applied Sciences, of Syracuse University. Mr. Kent is widely known in engineering circles as a man far above the average in ability and has had thirty years' of practical engineering experience. He was graduated from the Central High School, of Philadelphia, in 1868 and from the Stevens Institute of Technology, Hoboken, in 1876. Shortly after the latter graduation he was appointed editor of the *American Manufacturer and Iron World*, which position he held for two years and then resigned in order to engage in active engineering. Since 1890 he has been a consulting engineer, and during the past eight years, an associate editor of the *Engineering News*. Mr. Kent's name is probably familiar to a larger number of steam and mechanical engineers than that of any other man of present times, owing to the widespread popularty of his Mechanical Engineers' Pocket Book.

TRADE PUBLICATIONS.

MODERN LUBRICATION OF ENGINE BEARINGS. Pittsburgh Gage & Supply Company, Pittsburgh, Pa.—A handsomely executed folder devoted to the merits of the White Star continuous oiling system for steam engines.

TRANSFORMER INSULATION. General Electric Company.—Publication 9121 devoted to the permancy of transformer insulation, and containing a very complete account of the methods used by the General Electric Company in constructing and insulating Type H. transformer.

AMERICAN AIR COMPRESSORS. American Air Compressor Works, New York.—Catalogue A, containing illustrations and brief descriptions of single and duplex steam-driven compressors, single and duplex belt-driven compressors, duplex compound steam-driven air or gas compressors, vacuum pumps, etc.

MOND GAS. R. D. Wood & Company, Philadelphia, Pa.—This is a very handsome publication devoted to a discussion of Mond gas, its origin, production and advantages. The book is well illustrated, and contains a vast amount of useful information concerning Mond gas producers.

APPLICATION OF STORAGE BATTERIES TO RAILWAY PLANTS. The Electric Storage Battery Company, Philadelphia.—Bulletin No. 77, consisting of an illustrated folder containing a brief description of the Alum Rock battery station of the San Jose & Santa Clara Railway Company.

INSULATING MATERIALS. Dielectric Manufacturing Company, St. Louis, Mo.—A folder of vest pocket size, containing extremely useful and interesting charts, the cruves of which show the break-down potentials of air, mica, leatheroid, fullerboard, transformer oil and dielectrol, the latter material being a special insulating compound manufactured by this company.

NEWGARD WATERPROOF GLOBE.—The W. G. Nagel Electric Company, Toledo, Ohio.—A vest pocket folder in which is illustrated and very fully described a new combined waterproof globe and receptacle or lamp socket for incandescent lamps. The receptacle and cover of the globe are made in one structure, and the cover screws on to the mouth of the globe.

SAFETY DEVICES AND WIRE JOINTS. Chicago Fuse Wire & Manufacturing Company, Chicago, Ill.—This is catalogue No. 14, which is made in convenient pocket size, and contains complete illustrated price-lists of fuse wires, fuse links, fuse blocks, telephone protectors, and improved wire connectors. The catalogue is neatly printed on green tinted paper, and the contents are arranged conveniently for reference.

MOTOR DRIVEN BUFFERS AND GRINDERS. Storey Motor and Electric Company, Harrison, N. J.—This is section A of the Storey Company's catalogue, and is devoted to grinding and buffing machines, which consist of the well-known Storey motor mounted on a pedestal, and fitted for buffing, polishing and grinding wheels on both ends of the shaft. The pedestal, of course, is provided with rests such as those used on an ordinary emery wheel frame.

HOTEL ANNUNCIATOR PRACTICE.—Electric Gas Lighting Company, Boston, Mass.—This is a well-executed catalogue containing an illustrated description of the Ross return-call annunciator. These annunciators are built with or without a telephone plug-board, electrical resetting attachment and automatic fire alarm attachment. The catalogue also illustrates the various parts of the telephone branch of the system.

INTERURBAN TELEPHONES. Stromberg-Carlson Telephone Manufacturing Company, Chicago and Rochester.—This is designated Bulletin No. 1, but it is in reality a handsomely executed catalogue. It contains a complete description, with illustrations, of all the telephone apparatus necessary in railway and interurban telephone systems. The apparatus is built in both the central energy and magneto signalling forms, and some extremely interesting special arrangements of apparatus for railroad dispatching service are shown.

ELECTRICAL GLASSWARE. The Century Glass Company, Bellaire, Ohio.—A catalogue of moderate size containing scale drawings of every form of plain arc lamp glassware now in use. The lines included are inner and outer arc lamp globes; dome, bell and flat glass shades, and the straight glass cylinders used on Western Electric arc lamps. The catalogue is the sixth edition of the Century Red Book, and is indispensable to users of arc lamps. A smaller catalogue designated No. 3 is also issued, which covers all modern shapes of incandescent lamp shades in opal glass.

BUSINESS NEWS.

THE LUNKENHEIMER COMPANY, Cincinnati, has been compelled by enormous growth in business to increase its foundry capacity over 50 per cent.

SWAN ELECTRIC MANUFACTURING COMPANY, New York, has removed its headquarters from 59 William Street to the Battery Park Building, 21 to 24 State Street.

THE JOHN A. STEWART ELECTRIC COMPANY, Cincinnati, Ohio, has moved into its new factory at Ludlow, Ky., where much better facilities will be enjoyed for handling its trade.

J. HOLT GATES & CO., Chicago, have been appointed Western agents by the Skinner Engine Company, Erie, Pa., and are also representing the Quincy Engine Company, builders of the Williams vertical cross-compound engine.

ELECTRIC CONTRACT COMPANY, New York. has moved to new quarters at 202 and 204 Centre Street. The company reports a brisk trade in its Evening Star flash lamps, dry batteries and other specialties.

ROSSITER, MacGOVERN & CO. has removed its general offices from 141 Broadway to the Whitehall Building, No. 17 Battery Place, New York. In this column last month it was erroneously stated that the company had removed to 6 and 10 Battery Place.

PATTISON BROTHERS, consulting engineers, of New York, have removed their offices to the Fuller Building at the intersection of Fifth Avenue and Twenty-third Street, commonly designated the Flatiron Building. The telephone number has been changed to 180 18th Street.

THE OHIO ELECTRIC WORKS, Cleveland, Ohio, has brought out an attractive line of battery fan motors for operation with either wet or dry batteries. The sizes range from 5 to 12-in. fan diameters. The 9-in. fan motor is said to require only ¾ ampere at 7 volts to drive the fan at 1600 r.p.m.

THE OTIS ELEVATOR COMPANY has given up its extensive suite of offices in the Empire Building, although the lease has not yet expired, and removed to the Whitehall Building, No. 17 Battery Place, in order to obtain more room, which has become necessary on account of growth in business.

THE NORTHERN WIRE AND CABLE COMPANY, Milwaukee, Wis., has been incorporated with a capitalization of $300,000 and will erect a plant in Milwaukee for the manufacture of lead-covered wires and cables for telephone, telegraph, electric light and power service. J. B. Adams is general manager of the new company, the headquarters of which are in the Wells Building.

ALLIS-CHALMERS COMPANY, the well-known manufacturer of Reynolds-Corliss and Fraser & Chalmers engines, has obtained exclusive rights for this country to manufacture the Nurnberg gas engine which has been so successful in Europe, having been built there by the Augsberg-Nurnberg Manufacturing Company. The engine is of the double-acting four-cycle type and usually built in tandem form.

J. G. WHITE & CO., New York, have been appointed consulting electrical engineers for the New York & Jersey Railroad Company, and will have entire charge of the electrical equipment of the company's terminals and tunnels under the Hudson River; the rolling stock equipment, distribution system, signal apparatus and all other details connected with the electrical part of the project.

THE WESTINGHOUSE AIR BRAKE COMPANY has developed what is said to be an entirely new system for controlling electric motors on railway trains. The new system combines the air-brake mechanism and the motor-control mechanism so as to give the motorman absolute control of the train in the simplest possible manner. The company has also perfected a new automatic car coupling which unites in a single operation the electric and brake-pipe connections between cars.

THE THOMAS E. CLARK WIRELESS TELEGRAPH & TELEPHONE COMPANY, Detroit, Mich., reports a gratifying increase in business.

It is stated that many sets of Clark wireless telegraph apparatus are in use by the United States government in the Philippines, and that orders have been recently received from the Mexican government and the Georgia School of Technology, Atlanta, Ga.

THE STROMBERG-CARLSON TELEPHONE MFG. CO., of Chicago, Ill., and Rochester, N. Y., has about completed the installation of a multiple switchboard with 2400 lines present capacity and 4800 ultimate capacity for the Interstate Telephone and Telegraph Company at Springfield, Ill. The Interstate Company has nearly completed its underground system, which extends over the greater part of the city.

THE VOUGHT-BERGER COMPANY, La Crosse, Wis., reports among recent orders one from the Redwood County Telephone Company for one hundred bridging sets and a number of series instruments; one from J. C. Siegler, Nodine, Minn., for a switchboard and fifty bridging telephones for the new farmers' lines centering at that place; switchboards for Highlandville and Postville, Iowa, Grantsburg, Minn., and La Crosse, Wis.; together with a number of orders for bridging instruments and farmers' lines equipment.

CHANGE OF NAME.—The constantly increasing demand for Christensen air brakes and "Ceco" electrical machinery has made a change of the Christensen Engineering Company's organization necessary, and the owners of the stock of the Christensen Company have therefore organized the National Electric Company, to which the assets, good will, etc., of the old company have been transferred. The purposes, ownership, management and control of the new company are identical with those of the old, the only essential change being in the name.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY continues almost snowed under with orders for alternating-current equipment. Among recent sales may be mentioned three direct-driven three-phase alternators of 1000 kilowatts output each and one 300-kw machine, with exciters, to be installed in the White Mountain Paper Company's mill at Portsmouth, N. H. The machinery of the mill will be driven by Type C Westinghouse induction motors aggregating 5500 horse-power. When completed, this installation will, it is said, be the largest electrical equipment in any paper mill in the world.

THE CHRISTENSEN ENGINEERING COMPANY, Milwaukee, has been compelled by constantly growing business to obtain increased office facilities in Chicago; consequently a large office, fully equipped with every convenience, has just been opened in the Old Colony Building, where representatives of both the air brake and electrical sales departments will be pleased to welcome the customers and friends of the company. Chas. G. Burton, Chicago sales manager for "Ceco" electrical machinery, has removed from the Merchants Loan & Trust Building into the new office The air brake department is in charge of J. E. Eldred, Jr., who is well known in the electric railway field.

THE PNEUMATIC SIGNAL COMPANY has purchased from S. Marsh Young, owner of the Young system of automatic electric track circuit block signals for electric railways, all of his rights for the United States, Canada and Mexico, and will put the system on the market in the immediate future. The Young sysem is said to furnish the same class of protection for electic lines as the Standard railroad system used by steam roads supplies for that class of road. The Pneumatic Signal Company's factory, which has been at Troy, N. Y., until recently, has been removed to new quarters at Rochester, N. Y., where the company will have a floor space of 240,000 square feet.

H. C. ROBERTS ELECTRIC SUPPLY COMPANY, Philadelphia, has recently moved into its new four-story building at 905 Arch Street, and now has what is said to be the largest strictly electrical supply house in the state of Pennsylvania. The new building is owned by the company and covers a space of 25,000 square feet. The company carries in stock a full line of all of its specialties with the exception, of course, of large generators, motors and complete switchboards, which no house carries in stock. The growth of the business since its inauguration five years ago has been phenomenal, as indicated by the present occupancy of the new building.

FIELD & HINCHMAN, the well-known consulting engineers of Detroit, have combined with Mortimer L. Smith & Son and incorporated under the name of Field, Hinchman & Smith. On account of rapid increase in business, the firm has secured larger quarters in the Washington Arcade Building and established a branch office at Windsor, Ontario, Canada. One of the features of the firm's work is the design of complete power and industrial plants, including the buildings, which, it is scarcely necessary to say, are planned with a view to the needs of the plant.

THE PELTON WATER WHEEL COMPANY, San Francisco and New York, received contracts recently for water wheels for the largest hydraulic electric plants west of Niagara Falls. The heads under which the wheels are to operate range from 65 feet to 2100 feet. Three wheels of 3000 horse-power each are to go in the power house of the Vancouver Power Company, under a 390-ft. head; two wheels of 3000 horse-power each have been ordered by the Northern California Power Company to operate under a 1150-ft. head, each driving two generators by means of flexible leather link couplings; The Siskeyou Electric Power Company, of Yreka, Cal., is to put in a 1000-h.p. unit to operate under a 689-ft. head, and the Pike's Peak Hydro-Electric Company will install three Pelton wheels to operate under an effective head of 2100 feet and drive three 750-kw. generators.

THE NERNST LAMP.—Some of the streets of the city of Madison, Wis., are now being partly illuminated with Nernst lamps. The absence of flicker and shadow on the street make this lamp especially adaptable for out-door lighting. The movement is spreading and it is highly probable that the streets will be generally lighted with these celebrated little lamps. The popularity of the lamp for indoor illumination is also increasing rapidly. J. Harkness Brown, of Cleveland, Ohio, recently closed a contract with the Nernst Lamp Company for over 1500 Nernst lamps, which are to be used for lighting his large department store on Euclid Avenue. The Nernst lamp is especially fitted for illuminating dry goods stores on account of the "daylight" quality of the light, which renders a correct determination of color possible.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, closed recently a number of interesting contracts for "Chloride" accumulators. Among these were installations for lighting plants on five yachts under construction at Morris Heights, N. Y.; an installation of 480 amperes capacity for the Savannah Electric Company's power house, and a large number of isolated plants. The Savannah battery will be used in connection with both the lighting and railway systems and operated in conjunction with a special motor-driven booster. Among other railway installations may be mentioned one of 288 cells with a capacity of 628 kilowatt-hours to be installed in the station of the Seattle Electric Company, and a battery of 264 cells with a capacity of 740 kilowatt-hours for the power house of the Reading Power Company, Reading, Pa. The isolated plant equipments include one for the Astor Hotel, New York, and residential plants for Reginald Vanderbilt, at Portsmouth, R. I.; Thomas Morrison, Pittsburg, Pa., and J. J. Riker, Port Chester, N. Y.

SOLID TRAINS TO NORTHERN MICHIGAN.

The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.

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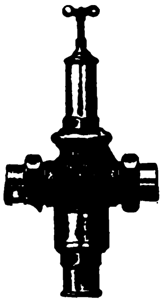

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American Electrician.

Vol. XV. New York, July, 1903. No. 7.

ELECTRICAL AND STEAM EQUIPMENT OF A HARDWARE FACTORY.

THE LIGHTING AND POWER PLANT OF LANDERS, FRARY & CLARK.

BY W. G. VIALL.

The lighting and power plant recently installed at the works of Landers, Frary & Clark, New Britain, Conn., furnishes an excellent example of the substitution of electrical power distribution for shafting and belts in a manufacturing establishment. The beginning of the present equipment dates back about five years, at which time the increasing business required more power than the steam plant then in use was capable of furnishing. As a result, a 10-h.p. direct-current 500-volt motor was installed, current being furnished by the local lighting company, which was supplying current for a few lights in the works. As business continued to increase many lights were added and more power was needed. To meet this condition, a 125-volt direct-current dynamo of 900 lights capacity was installed and driven by the engine which had previously been used to drive the factory, and two or three motors were installed. More lights and motors were added from time to time until the lighting dynamo became overloaded, there being some 1100 lights in use. This situation called for a radical change in the lighting plant, and as there were ten motors in operation with a total capacity of 200 horse-power it was considered advisable to put in a plant for furnishing both light and power, which was accordingly done. This plant has been running steadily for many months, and has not only furnished an exceedingly satisfactory service, but has proved a good investment.

The power house is a one-story brick building 100 ft. long by 40 ft. wide. It is centrally located, being nearly surrounded by the factory buildings in which the current is used. A brick wall forms the dividing line between the engine and boiler rooms, the latter being 44 ft. long. The boiler plant consists of three 160-h.p. boilers, made by the D. M. Dillon Steam Boiler Works, of Fitchburg, Mass. They are of the horizontal return tubular type, set with over-hanging cast iron fronts. The shells are 6 ft. in diameter by 19½ ft. long, and of the best open-hearth homogeneous steel, ½ in. thick. The heads are of open-hearth flange steel 9-16 in. thick, braced at each end above the tubes with 23 braces of the solid crowfoot type. Each boiler contains 92 seamless steel tubes 18 ft. long and 3½ ins. in diameter. The grates used are the improved Sheffield, with ½ in. air spaces, and they are 72 ins. long by 66 ins. wide. In placing the boilers no

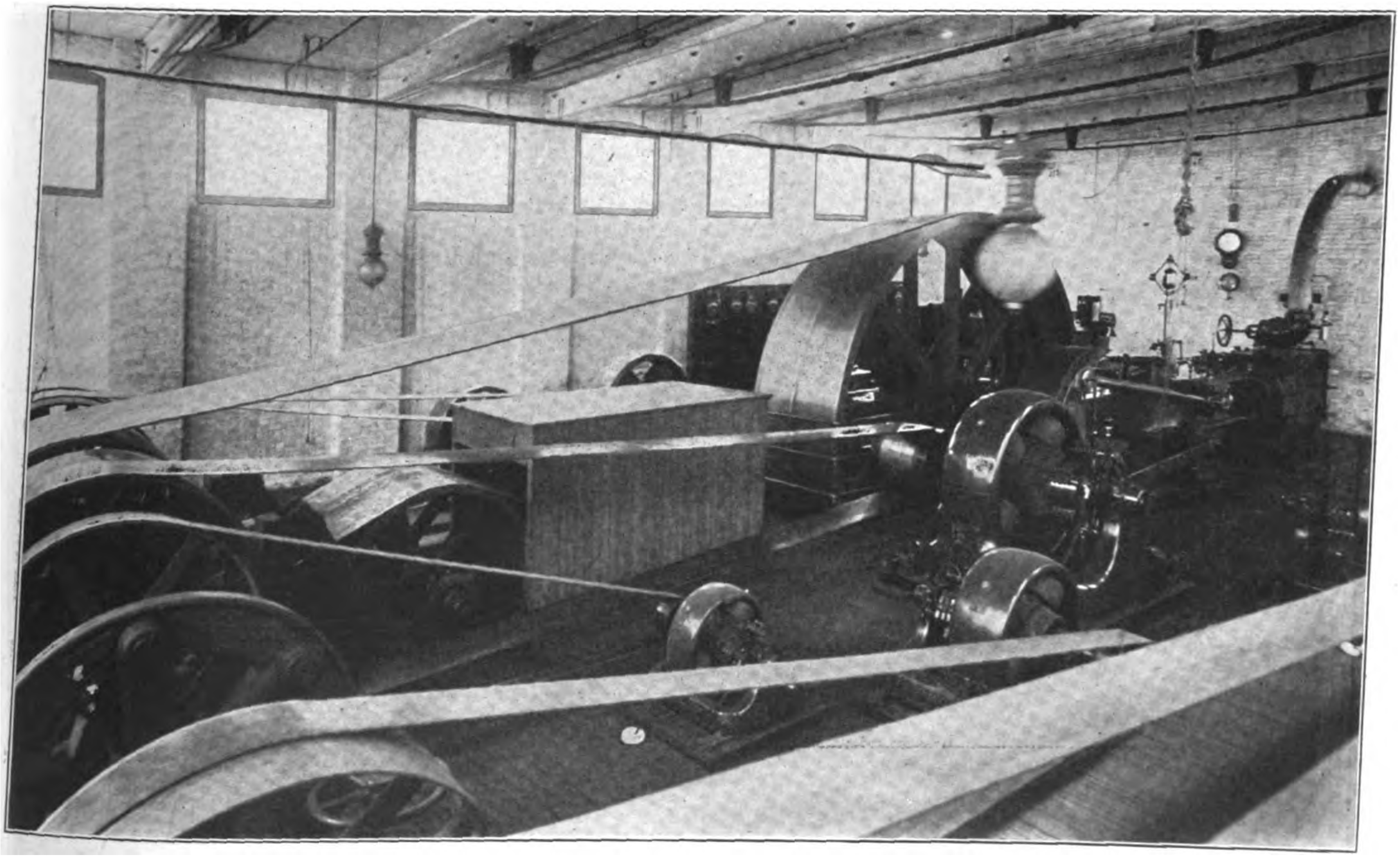

FIG. 1.—VIEW OF ENGINE ROOM IN WORKS OF LANDERS, FRARY & CLARK.

back stays were used, the boilers being suspended by four heavy iron girders, two on each side, before the brickwork was commenced. This rendered unnecessary the blocking ordinarily used to hold the boiler in place, and gave free access to both sides of the side walls during construction, as well as leaving the boilers entirely independent of the side walls for support. Each boiler is equipped with the usual fittings.

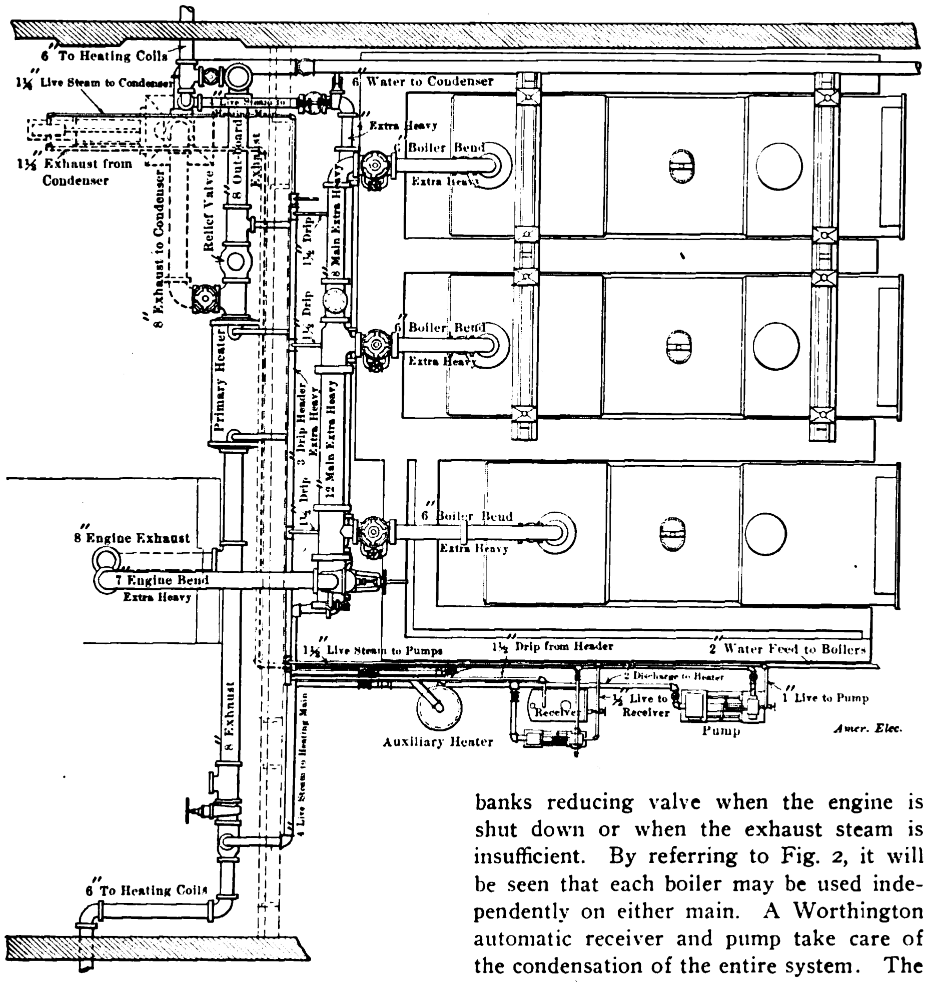
6" To Heating Coils
1¼" Live Steam to Condenser
1⅛" Exhaust from Condenser
8" Exhaust to Condenser
Relief Valve
8" Out-board Exhaust
4" Live Steam to Heating Main
6" Water to Condenser
4" Extra Heavy
6" Boiler Bend
Extra Heavy
1¼" Drip
8" Main Extra Heavy
Primary Heater
3" Drip Header Extra Heavy
12" Main Extra Heavy
8" Engine Exhaust
7" Engine Bend
Extra Heavy
1½" Live Steam to Pumps
1½" Drip from Header
2" Water Feed to Boilers
2" Discharge to Heater
¾" Live to Receiver
1" Live to Pump
Receiver
Pump
Auxiliary Heater
8" Exhaust
6" To Heating Coils
Amer. Elec.

FIG. 2.—PLAN VIEW OF STEAM PIPING.

The boiler fronts are protected by Lamphry boiler furnace-mouth protectors through which water circulates, absorbing the intense heat to which the fronts would otherwise be subjected, and obviating the liability to burning out cheek and arch castings or cracking and warping the fire doors. This also forms an important addition to the heating surface of the boiler, as the temperature of the water passed through the protector is, of course, greatly increased. The draft is controlled by a Spencer automatic damper regulator, and the firing is done by hand. The fuel used is soft coal. The gases are carried off through a 4-ft. flue to a 90-ft. steel stack 4 ft. in diameter, 7-16 in. thick, mounted on a 15-ft. sub-base of brick, making the total height 105 ft. The sub-base is 6 ft. square at the top and 8 ft. square at the bottom, and rests on a heavy concrete foundation.

All high-pressure steam pipes are of extra heavy steel, and the feed-water piping is heavy brass from heaters to boilers. Fig. 2 shows the arrangement of piping. Each boiler feeds into a large steam main located directly above the passage at the rear end of the boilers from which the engine is supplied. A small steam main which runs along the wall back of the boilers also connects with each one. This small main is used for manufacturing purposes and supplying the heating system through a Fairbanks reducing valve when the engine is shut down or when the exhaust steam is insufficient. By referring to Fig. 2, it will be seen that each boiler may be used independently on either main. A Worthington automatic receiver and pump take care of the condensation of the entire system. The feed-water is pumped through two heaters, a National and an American, by a duplicate set of pumps. The engine exhausts through the National heater, and the pumps exhaust through the American. A Jenkins back-pressure valve is used to supply the necessary pressure to the heating system.

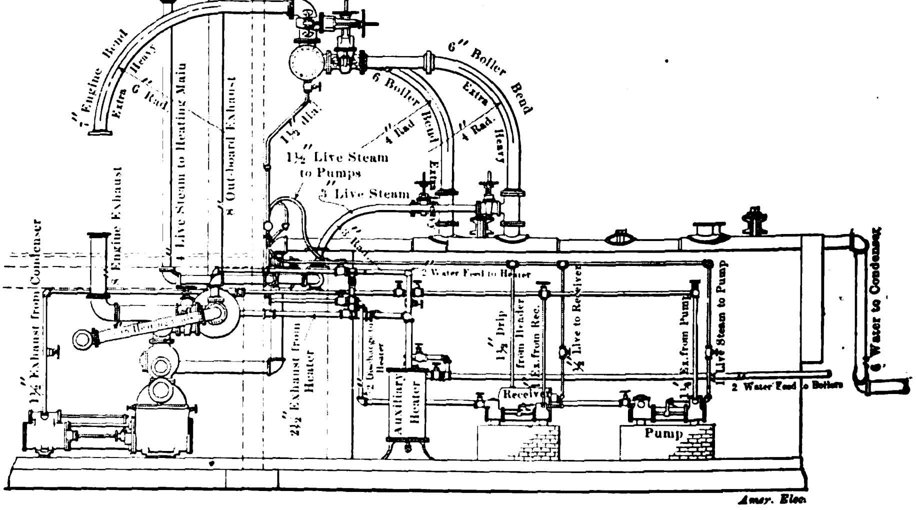
7" Engine Bend Extra Heavy
4" Live Steam to Heating Main
8" Out-board Exhaust
6" Boiler Bend
6" Boiler Bend Extra Heavy
1½" Live Steam to Pumps
3" Live Steam
4" Rad.
3" Rad.
1½" Exhaust from Condenser
8" Engine Exhaust
2½" Exhaust from Heater
2" Discharge to Heater
Auxiliary Heater
2" Water Feed to Heater
1½" Drip from Header
Ex. from Rec.
¾" Live to Receiver
Receiver
1¼" Ex. from Pump
1" Live Steam to Pump
Pump
2 Water Feed to Boilers
6" Water to Condenser
Amer. Elec.

FIG. 3.—ELEVATION OF STEAM PIPING.

The engine, which is of the Corliss type, was built by the William A. Harris Steam Engine Company. It is equipped with double eccentrics and the Brown valve-gear. The cylinder is 20 by 42 ins. and the speed is 90 r.p.m. The engine is rated at 360 horse-power when working under 125 lbs. steam pressure. The driving wheel is 15 ft. in diameter, with a 4-ft. face; it is belted to a jack shaft at the end of the building, from which the dynamos are driven. Elephant brand canvas-center belting is used throughout the plant. A friction clutch is inserted in the jack shaft near one end, so that two of the dynamos may be driven by a small engine at times when the load is too light to be run economically by the large engine.

The electrical equipment of the plant consists of six General Electric compound-wound direct-current multipolar dynamos ranging in size from 9 to 85 kilowatts. They are controlled from a polished black slate switchboard upon which are mounted the necessary switches and instruments. Two 85-kw. 500-volt dynamos are used for the regular day power load and a 25-kw. dynamo is held in reserve. These three machines are controlled at the three end panels on the right-hand side of the board (see Fig. 4). The three machines are arranged to work in multiple, and are connected through General Electric quick-break switches and Elden circuit-breakers to a pair of bus-bars from which the current passes to two Thompson recording wattmeters located at the top of the power feeder panel, which is the right-hand one of the two in the center of the board. Each of the meters is connected to a feeder switch beneath them. As the diagram indicates, the switches are double-pole double-throw; the upper terminals are connected to the meters mentioned, and the lower terminals to other meters (not shown) that are connected on the mains of the local lighting company, so that if the generating plant should break down, power could be obtained from the central station. From the middle terminals of the switches heavy feeders are run throughout the works for the distribution of power.

The three-wire system is used for lighting, with an extreme e.m.f. of 220 volts; the neutral wire is of one-half the cross-section of each of the outer wires. Two 45-kw. dynamos are used when the heaviest load is on, one being connected to each side of the system, and a 9-kw. machine is arranged to be used in multiple with either of the larger machines, should one side of the system become overloaded. These three dynamos are controlled from the three end panels at the left-hand side of the switchboard; all of them are 110-volt machines, of course. By referring to Fig. 5 it will be seen that each dynamo is connected to the center terminals of a double-throw switch; the upper terminals of this switch connect with an equalizer, the neutral bus-bar and the positive main bus-bar, and the lower terminals connect with another equalizer, the neutral and the other main bus-bar. Throwing any switch upward therefore puts that dynamo on the positive side of the three-wire system and throwing it downward puts the dynamo on the negative side.

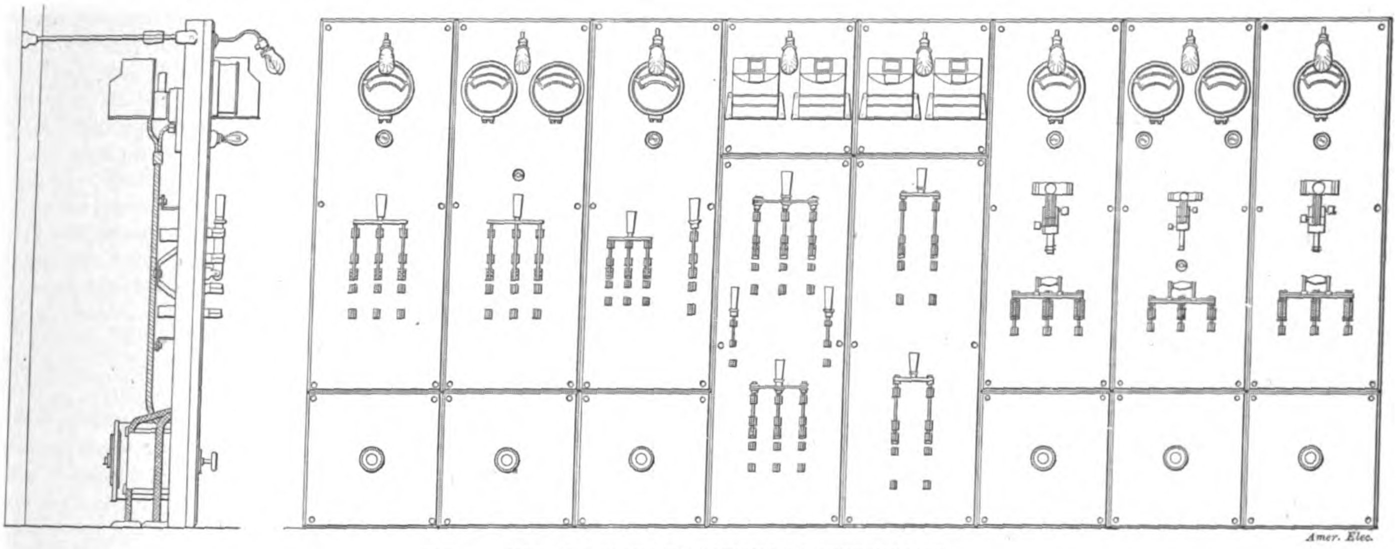

FIG. 4.—SIDE AND FRONT ELEVATIONS OF SWITCHBOARD.

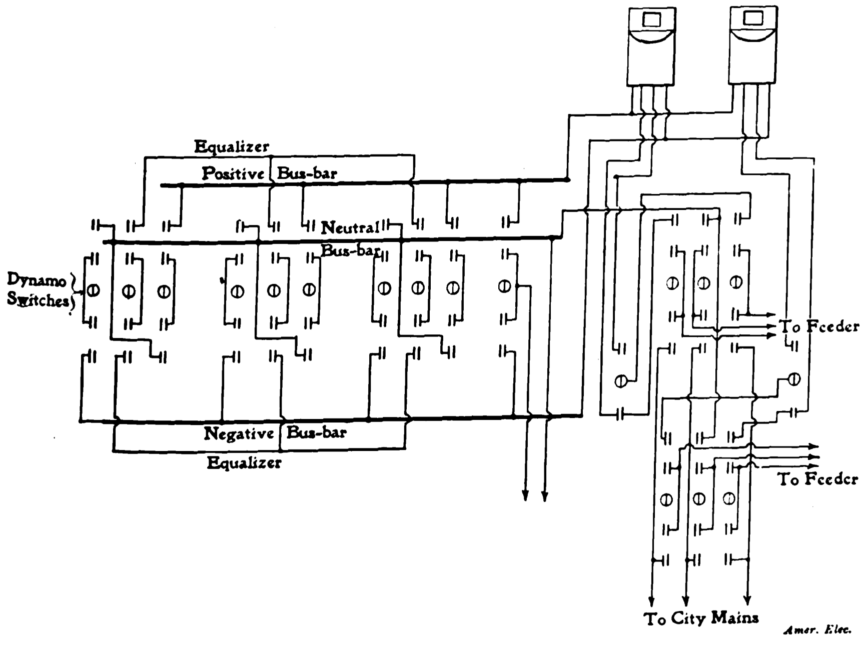

FIG. 5.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

One of the equalizers becomes active when all three dynamos are in use, the small dynamo being then in multiple with one of the larger machines.

The current after passing the generator switch goes through two three-wire Thompson recording wattmeters, each of which is connected to the upper terminal of three three-pole feeder switches just below it. These switches, as Figs. 4 and 5 indicate, are double-throw, the lower terminals being connected to the mains of the local lighting company. During the day, when the lighting load is small, the two single-pole double-throw switches shown on the same panel with the feeder switches are thrown down. This connects the two outside wires of the system together, making a two-wire system, which is usually fed by the 9-kw. dynamo.

There are seventeen motors in use throughout the factory buildings, part of Westinghouse and part of General Electric manufacture, ranging from 10 to 50 horsepower. Each motor drives a short lineshaft from which are belted the machines of one department of the works. The factory machines are all too small to justify the use of individual motors, and since grouping was necessary, it was done systematically by giving each motor a complete department to drive.

THE HEYLAND INDUCTION MOTOR.

BY A. S. M'ALLISTER.

When there is impressed upon the primary of an induction motor an e.m.f. of full normal value, the secondary being on open circuit and the rotor stationary, there is caused to flow within the windings a current the magnitude and phase of which can best be determined by ascertaining the value of its two components. Its power component is of a value such that its product with the circuit e.m.f. is just sufficient to supply to the motor the no-load power, consisting of primary copper loss and both primary and secondary iron loss. Its wattless or quadrature component has a value such that its product with the number of turns of the primary windings produces the requisite magnetomotive force to cause the flow, through the reluctance of its paths, of a magnetic flux of which the rate of change at each instant is proportional to the otherwise unbalanced primary e.m.f. The unbalanced primary e.m.f. referred to is that portion of the impressed e.m.f. which remains after subtracting (in proper phase position) the e.m.f. consumed by the local impedance of the primary windings due to the passage of the current therein. The observed primary current is the vector sum of the above named components, while the phase relation of the current with respect to the e.m.f. is given by that angle the cosine of which is equal to the power component divided by the observed current.

It is evident that in order to decrease the phase displacement between the current and e.m.f., it is necessary to render the power component and the observed current more nearly equal in value. This may be accomplished by one, or both, of two methods; *i. e.*, increasing the power component, or decreasing the wattless component of the current. The former method is that to which is due the increased power factor, or decreased phase displacement, with increase of load on the ordinary induction motor, the maximum power factor appearing when that condition is reached when the ratio of the power component to the wattless component is a maximum. If the wattless component remained constant in value an increase in load would always be accompanied by an increase in power factor. But owing to the existence, upon increase of primary and secondary currents, of local magnetic lines of force which flow in closed paths around the primary coil without enclosing any secondary conductors and around the secondary without enclosing any primary conductors, producing field distortion and a reduction of the flux common to both windings, the wattless component is increased with each increment of load and the rate of increase is much augmented as full load is approached and passed. Obviously, therefore, the result of loading an induction motor is not to decrease the lagging current below that value which the motor demands at no-load, though the increased power factor is frequently credited with reducing the undesirable effects which are caused by and proportional to the lagging wattless component of the primary current.

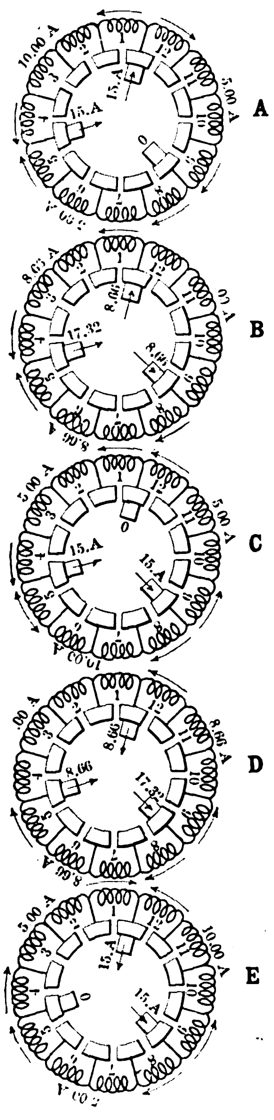

FIG. I.

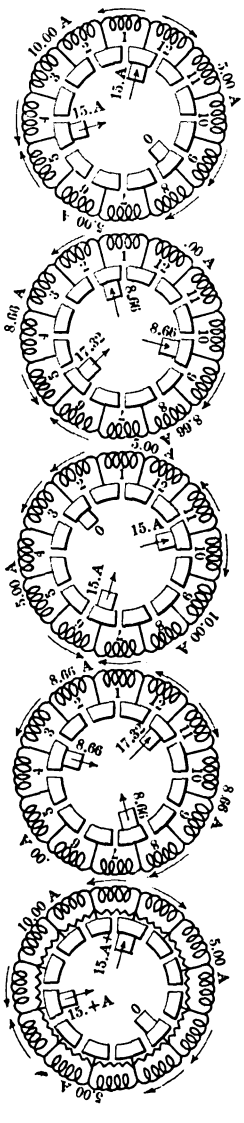

FIG. 2.

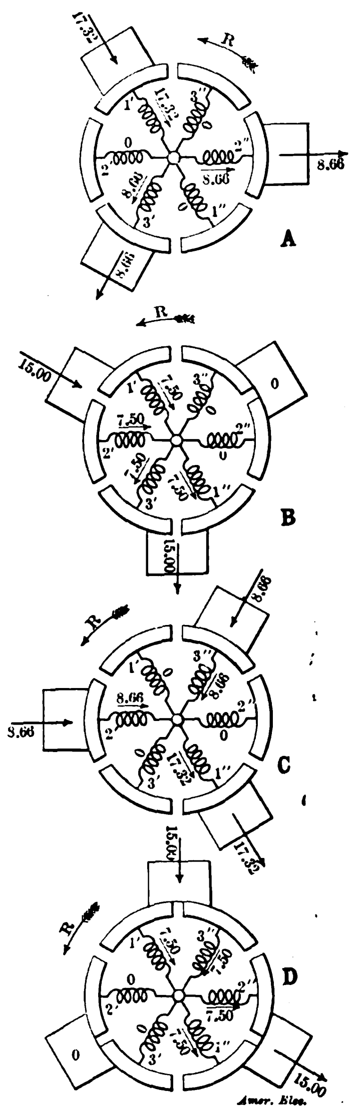

FIG. 3.

The most logical method of improving the power factor of operation of an induction motor is that which has for its object the reduction of the wattless component of the primary current. The employment of details of construction which lessen the tendency of the flux to close around one winding without encircling the other, tends to the reduction of the wattless current component with increase of load and thus improves the operating power factor and the mechanical performance of the motor, since the maximum torque which the rotor can exert and the overload which the motor can carry are determined almost wholly by the local reactance of the windings.

The amount of magnetic flux which the no-load wattless component of the current must produce is determined by the primary e.m.f. and frequency, and the value of the wattless component depends upon the reluctance of the paths which these lines must take. The major portion of this reluctance is found in the air-gap which forms the separating space between the rotor and stator. A reduction in the air-gap is followed by an almost proportional decrease in the inductive or wattless component of the current, which accounts for the fact that all modern induction motors are constructed with air-gaps as small as permitted by the requisite mechanical clearance between the stationary and revolving members of the machine. It is evident that much further improvement along this line can scarcely be expected.

Although it is for the purpose of producing counter e.m.f. in the primary that the core magnetism is required, it is not essential that the exciting current should flow in the primary windings; the magnetomotive force for excitation may with equal effect be supplied by current in the secondary, although the ampere-turns in the one case must equal those in the other.

Consider an induction motor with a stationary primary and a revolving secondary, the latter being coil wound, and, for simplicity of discussion, assume the secondary turns equal in number to the primary. Let the rotor be at rest and the secondary on open circuit. On applying normal e.m.f. to the primary windings there will flow a current having power and wattless components, as discussed previously. If the secondary be now interchanged for the primary winding in its connection to the external circuit, an exactly similar and equal current will be found to flow in the secondary winding. If both the primary and secondary windings be connected simultaneously to the external supply circuits, care being taken that the separate revolving fields due to the wattless current components in the two windings travel around the air-gap in the same direction, it will be found that at a certain position of the rotor relative to the stator the two windings combined take a current equal in value and character to that taken by each winding when connected up alone. By increasing slightly the e.m.f. impressed upon the secondary, the primary e.m.f. remaining as before, the wattless component flowing in the primary windings may be reduced to zero, or even given a negative value. Under this condition the quadrature component of the ampere-turns in the secondary windings has a value just sufficient to give the magnetomotive force to produce the requisite core magnetism to induce the desired primary counter e.m.f. The rotor is, however, stationary, and even resists any attempt at motion in either direction so that with connections arranged as just described no power can be obtained from the motor.

It is possible to supply the exciting magnetomotive force to the motor through the secondary windings while the rotor travels at full speed without any constructive change in the windings of the motor, as here assumed. Consider normal e.m.f. impressed upon the primary with the secondary on closed circuit and the rotor traveling at full speed. The wattless component of the primary current will have practically the same value as with the secondary on open circuit and the rotor stationary. If now there be introduced into the secondary windings direct current adjusted in value to equal the mean effective value of the wattless component of the primary current, as previously observed, it will be found that the lagging of the current in the primary windings has been reduced to zero, so that the power factor has increased to unity. The motor may now be given its full load and its performance will be found to be satisfactory in all respects.

It is well at this point to investigate the advantages and disadvantages of this latter arrangement. The core magnetism is not decreased in value, so that the exciting current is as large as ever, but the latter has been transferred from the primary to the secondary winding, and not only is its value the same as before, but because of the fact that when existing in the primary windings it was the wattless component of the working current, its heating effect upon the secondary windings is just equal to the reduction in heat loss in the primary windings; therefore no gain has been made through a reduction in heat loss.

Let $E =$ primary e.m.f.

$R =$ primary or secondary resistance.

$I_p =$ power component of primary current.

$I_q =$ exciting current, whether in the primary or secondary windings.

Under normal no-load conditions, the copper primary loss is

$$(\sqrt{I_p^2 + I_q^2})^2 R = I_p^2 R + I_q^2 R,$$

while the secondary copper loss at no-load is of practically zero value.

With direct current in the secondary winding, the copper loss there is

$$I_q^2 R,$$

and the primary copper loss is

$$I_p^2 R,$$

so that the total copper loss, $I_p^2 R + I_q^2 R$, in the two windings is the same as before.

Although the actual excitation loss in the primary under normal no-load conditions was $I_q^2 R$, the apparent exciting power was $I_q E$ in *addition* to the loss. This "wattless" current, I_q, is required to travel over the circuits and transforming devices between the generator and motor, and tends to decrease the field magnetism of the generator and to reduce further the e.m.f. at the receiving end of the transmission line. An elimination of this wattless component removes the greatest objection to the otherwise admirable induction motor.

With direct current supplied to its secondary windings an induction motor travels at synchronous speed and, in fact, becomes transformed to a synchronous motor and therefore possesses all of the qualities inherent in the performance of this type of machine. Mr. Heyland has devised a method, however, by which approximately unidirectional current may be supplied to the secondary windings while the motor yet retains the characteristics of the asynchronous type of machine.

According to the foregoing discussions it is plain that with the rotor traveling at synchronous speed, current of zero frequency may be utilized to supply the magnetomotive force for excitation, while with the rotor stationary, current at a frequency equal to that of the primary may thus be employed. A little further consideration will convince one that at speeds between synchronism and standstill current at intermediate frequencies may be so used, and that the requisite frequency in each case is equal to the product of the percentage of slip and the primary frequency. By attaching to the secondary windings a commutator, to the brushes upon which current is led at the primary frequency, the current in the secondary will, at any speed, possess the frequency required for excitation.

For the sake of simplicity in explanation, consider, in the first place, that upon the rotor there is placed a symmetrical direct-current armature winding with a corresponding commutator. By introducing into the windings an alternating current at the primary frequency, when the rotor is stationary, the effect will be exactly the same as was previously found when the current at the same frequency was supplied to the secondary of the ordinary induction motor with stationary rotor; that is, by adjustment of secondary current, the wattless component of the primary current may be made to disappear. If, however, the rotor be given a certain speed, the same current in the secondary will continue to produce the same magnetizing effect as at standstill, for at each instant the commutator will cause the current to traverse conductors occupying the same position in space, and the effect of the secondary current upon the primary core magnetism will not be altered.

TABLE I.

Instantaneous values of currents in each coil of direct-current winding; three-phase excitation; rotor stationary. (Fig. 1.)

Number of coil.	A	B	C	D	E	F
1	+10.00	+8.66	+5.00	0.00	—5.00	—8.66
2	+10.00	+8.66	+5.00	0.00	—5.00	—8.66
3	+10.00	+8.66	+5.00	0.00	—5.00	—8.66
4	+10.00	+8.66	+5.00	0.00	—5.00	—8.66
5	—5.00	—8.00	—10.00	—8.66	—5.00	0.00
6	—5.00	—8.00	—10.00	—8.66	—5.00	0.00
7	—5.00	—8.00	—10.00	—8.66	—5.00	0.00
8	—5.00	—8.00	—10.00	—8.66	—5.00	0.00
9	—5.00	0.00	+5.00	+8.66	+10.00	+8.66
10	—5.00	0.00	+5.00	+8.66	+10.00	+8.66
11	—5.00	0.00	+5.00	+8.66	+10.00	+8.66
12	—5.00	0.00	+5.00	+8.66	+10.00	+8.66

Fig. 1 represents such symmetrical armature winding upon the commutator of which are placed three brushes for the introduction of three-phase current for excitation. The instantaneous values of the current in the individual coils as the current in the three-phase leads changes value are indicated for each 30 degrees increment of time in the several diagrams of Fig. 1, and collectively recorded in Table I. The rotor is here assumed to be stationary. It will be observed that throughout each cycle the current in each coil undergoes a double reversal and reaches full normal value in both positive and negative directions. The reactive e.m.f. induced in the windings, which is proportional to the rate of change of the local flux surrounding the conductor due to the current flowing therein, is therefore of a value corresponding to the primary frequency, and there is required for the secondary excitation a wattless component equal to that which would have been required had the exciting current been allowed to flow in the primary windings.

TABLE II.

Instantaneous values of currents in each coil of direct-current winding; three-phase excitation; synchronous speed. (Fig. 2.)

Number of coil.	A	B	C	D	E	F
1	+10.00	0.00	+5.00	+8.66	+10.00	0.00
2	+10.00	+8.66	+5.00	+8.66	+10.00	+8.66
3	+10.00	+8.66	+5.00	+8.66	+10.00	+8.66
4	+10.00	+8.66	+5.00	0.00	+10.00	+8.66
5	—5.00	+8.66	+5.00	0.00	—5.00	+8.66
6	—5.00	—8.66	+5.00	0.00	—5.00	—8.66
7	—5.00	—8.66	—10.00	0.00	—5.00	—8.66
8	—5.00	—8.66	—10.00	—8.66	—5.00	—8.66
9	—5.00	—8.66	—10.00	—8.66	—5.00	—8.66
10	—5.00	0.00	—10.00	—8.66	—5.00	0.00
11	—5.00	0.00	+5.00	—8.66	—5.00	0.00
12	—5.00	0.00	+5.00	+8.66	—5.00	0.00

When the rotor is traveling at a speed approximately synchronism the exciting current required in the secondary windings is of the same value as before, but the requisite wattless component is much reduced because of the decrease in the reactive e.m.f. of the secondary windings. With an infinite number of commutator segments and of phases for the exciting current in the secondary, the reactive e.m.f. would entirely disappear at synchronous speed, and it would increase directly with the rotor slip. Fig. 2 indicates the changes in the value of the secondary current in the individual coils with three-phase excitation, when the rotor is traveling at synchronous speed. For the sake of clearness the windings are considered stationary and the brushes are supposed to revolve at synchronous speed, the effect being the same as with stationary brushes and revolving windings, of course.

A glance at Table II will show that the fluctuations in the current in the individual coils are much reduced at synchronous speed, and consequently the flux around the conductors, to the rate of change of which is due the reactive e.m.f., has a much more nearly constant value than when the secondary is stationary, and thus the necessary wattless component for secondary excitation is correspondingly diminished.

The value of the e.m.f. for excitation will depend upon the number of and resistance of the secondary conductors and upon the reactive e.m.f., and will in general be much below that required for the primary windings. It can conveniently be obtained by transformation from the supply circuit. An increase in the excitation e.m.f. above normal value will cause the primary to draw leading currents, the value of which may be adjusted to equal the lagging current demanded by the primary of the excitation transformers, so that the motor and transformers considered as a unit may be operated at unity power factor.

In order that the rotor shall be drawn into rotation by the revolving field, it is necessary that the secondary circuit be closed. This is accomplished by connecting resistance between the adjacent commutator segments, as indicated at position *E* of Fig. 2. Since the current induced in the secondary, due to the slip of the conductors relative to the revolving field, must pass through these resistance coils, which are, in fact, in series with the secondary windings of the machine considered as an induction motor, it is desirable to make the resistance as low as possible, for the slip due to any given torque and the secondary loss due to a given current depend directly on the total resistance of the secondary circuit. But on account of the fact that these resistances form a parallel path for the exciting current from the lowering transformers, it is desirable, in order to decrease the shunt loss, that the resistance be large. The resistance is, therefore, given a value large in comparison with that of the armature winding, but small enough not to increase unduly the total secondary resistance.

The resistance forms a non-inductive shunt to the inductive windings of the armature, and thus serves the very advantageous purpose of suppressing any sparking at the excitation brushes; which fact allows the use of copper brushes of cross-section much less than that required for carbon brushes and the commutator is given a correspondingly smaller size. So effective is the elimination of sparking that no observable result is produced by shifting the brushes into any position, and the commutator operates as satisfactorily as slip rings.

In order to reduce the reactive e.m.f. of the secondary below that value which it is possible to obtain with the direct-current winding, there has been developed a double, semi-parallel connected three-phase winding which possesses many advantages. This winding is diagrammatically represented in Fig. 3, which indicates also the changes in value of the secondary current when the rotor (brush) is traveling at synchronous speed. The winding is connected double star fashion. Coils 1' and 1" lie in the same slots; coils 2' and 2" lie in the same slots, and the same is true of coils 3' and 3". The object of this arrangement is to maintain as nearly constant as possible the local flux surrounding each individual conductor, and thereby reduce as far as possible the reactive e.m.f. The flux encircling a slot depends upon the current flowing through the slot, but it is not altered by a change of the current from one conductor to another in the same slot. By the present arrangement, when the current in one conductor occupying a certain slot has its zero value the other conductor carries its maximum current, and, as Table III shows, the actual current which causes local flux around the separate coils undergoes but slight variation in value. The reactive e.m.f. is, therefore, quite small, and the secondary wattless component is much reduced, so that the exciting transformers may be of small capacity and operated at high-power factor; moreover, a relatively slight increase in e.m.f. at the excitation brushes causes the leading current in the primary windings of the motor to compensate for the lagging current in the transformers, giving to the machine, as a whole, a power factor of unity. By adjusting the degree of over-excitation at no-load and shifting the secondary brushes the requisite amount in the proper direction, the compensation may be made such as to hold the power factor at practically unity at all loads within the operating range of the motor.

TABLE III.

Instantaneous values of currents in each slot; three-phase winding; three-phase excitation; synchronous speed. (Fig. 3.)

Sections of coils in slots 1, 2 and 3.	A	B	C	D	E	F
1'	17.32	7.50	0.00	7.50	17.32	7.50
1"	0.00	7.50	17.32	7.50	0.00	7.50
2'	0.00	7.50	8.66	0.00	0.00	7.50
2"	8.66	0.00	0.00	7.50	8.66	0.00
3'	8.66	7.50	0.00	0.00	8.66	7.50
3"	0.00	0.00	8.66	7.50	0.00	0.00
Coils in slots 1, 2 and 3.						
1	17.32	15.00	17.32	15.00	17.32	15.00
2	8.66	7.50	8.66	7.50	8.66	7.50
3	8.66	7.50	8.66	7.50	8.66	7.50

The three-phase winding allows of the introduction of resistance in the secondary windings by means of slip rings connected at the center of the "star," and the starting torque or operating speed can thus conveniently be varied at will.

On account of the reduction in the effective secondary reactance and the elimination of the wattless current component in the primary windings, the compensated induction motor may be given a much greater load than the corresponding motor without compensation, while the ability to supply even an enormously increased magnetomotive force for excitation allows the compensated motor to be given a larger ratio of current-conductor material to magnetic material, especially upon the secondary, in which the iron loss in any case is relatively small. Consequently, by the use of the specially-wound secondary with commutator and transformers, the capacity of a given induction motor may be much increased, or, and for the same reasons, an induction motor of a given capacity may thus be constructed at a proportionately less cost.

It is scarcely probable that the mere elimination of the wattless current component from the circuit wires would prove sufficient inducement to a consumer to justify the extra expense of adding a commutator and the accompanying complications to the one piece of reliable machinery, the simplicity of which has previously been the characteristic that led most rapidly to its adoption in preference to commutator motors. The ability of manufacturers to produce at a reduced cost motors giving satisfactory service to the purchaser can alone cause the compensated motor to compete successfully with its highly efficient and, above all, simple rival.

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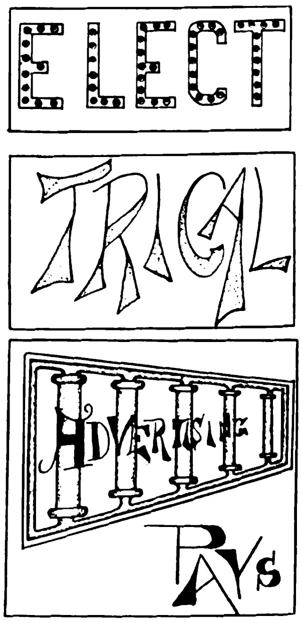
Breaking of Loop Wires.—The breaking of the loop wires connecting arc lamps to cross arms and line may be prevented by using flexible cable instead of solid conductor wire. Where the latter is used a good plan is to coil up the wire in several turns or loops at insulators and at the lamp and cross arm. Then support the wire by a rope sling holding its weight and relieving it from any strain.—*Exchange.*

ELECTRICAL DISPLAY SIGNS.

BY GEO. RICE.

It is hardly necessary to inform the electrical engineer and machinist of the fact that during the past year or two there has been a very marked advancement in the designing and building of electrical display advertising signs. The writer has been investigating the progress made in electrical signs, and gives in the annexed views some ideas concerning their design. In some of the localities which I visited I met experts who devote all their time and energies to producing new and original ideas in electrical sign work. In other places, very artistically-arranged signs are the product of men engaged at other lines of work in the electrical shop. All agree, however, that the call for novelties in electrical display signs has increased to a noticable degree recently. One may observe this condition in passing through the business streets of a live city or town. There he will note some very unique presentations in varied colors of the electrical lights, and in all manner of settings.



FIGS. 1, 2 AND 3.

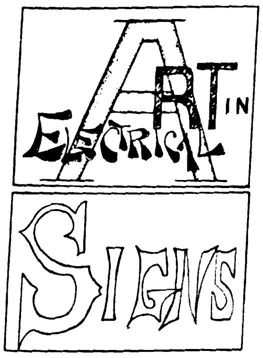
The demand which was at first for the plain set letters, is now developing into a call for letters with scroll work, floral devices, and artistically-arranged backgrounds. The designer is obliged to avoid submerging the sign in a cloud of floral effects in finely-finished lines and settings, yet he is compelled to present something more than the straight, set letters which were popular not long ago. In Fig. 1, for example, is a very good letter, which is always plan and appropriate. But one often sees letters of the class presented in Fig. 2. This style is made on the free-hand idea, without any positive setting for formations, and often letters become less easy to read than the sign made with the staid letters of Fig. 1. However, the electrical sign designers find it essential to keep up with the requirements of the time, regardless of the readable qualities of the wording.

Not long ago a background or set work

for the electrical sign was hardly ever used. Now-a-days one sees very many signs in front of the best and largest houses, on which there is a background. Fig. 3 shows one form of ground work used advantageously in such signs. The pillar or post idea is developed with sheet metal formations, just as the letters are made, and the effect, when the letters are adjusted, is striking. There are quite a number of signs in service in commercial centers in which the grounding is of a clever character, and the writer was struck with the originality of some of them. The base work is frequently finished with colored effects, so that in looking at the sign from a distance the various hues are brought out in pleasing presentation.

The writer has visited a number of electrical sign "studios" in which there seemed to be an unlimited collection of designs of this order from which a buyer could choose. Often the sign is in a crude state, and kept that way until the purchaser decides upon the working. He is shown the effect produced by taking the sign into a dark room, where it is fixed up with any types of words and lines, and he can gauge his orders accordingly.

In a few of the largest institutions in which electrical sign designing is carried on, quantities of electrical sign work from European countries are used as illustrations for the modeling of new signs. The English signs seems to carry considerable heavy and awkward-appearing letters and set pieces, while the French signs are quite finely outlined in all details. The different forms of signs are used as patterns in combination, and the plan of combining ideas is resulting in some very good electrical sign work.



FIGS. 3 AND 4.

Some of the signs in American centers appear to have been built up by tossing words into the design, something after the fashion indicated in Fig. 4. It would seem as if there were merely a jumble in this setting, and yet in the designing of the sign the artist studied the causes and effects faithfully. The idea is to have the different words in different colors, so that when the sign is mounted high in the air in front of the store one may see the colored effects at a long distance.

A feature of electrical sign-making is the preparing of designs on the order of the one shown in Fig. 5, in which the lettering is produced only in line effect, to be worked out by the finishers of the signs. Hence, one finds that one branch of the business calls for the employment of men who do nothing else but design line letters of the order shown in this sample. The letters may be very plain or they may abound with scrolls and florals. In some cases shading is required, and again, the letters must be fitted to some special effect which goes with the sign.

What may be termed separate electrical signs in various forms have become popular in the advertising business. One may pass through the advertising sections of a busy city and he will observe that some of the signs are suspended, as in the case of an ordinary swinging sign. Again, a complete form of an easel may be seen on a background of white metal, and this easel may carry on it a sign bearing descriptive wording to suit the goods advertised, or the business represented. Animals are shown with good effect. I recollect a horse shown with a saddle blanket on him, and on this blanket were the words for advertising the blankets made and sold by the advertisers. Carriages are now well-designed in electrically-lighted signs; also bicycles, typewriters, cameras and hundreds of others articles. The professional electrical sign designer is finding his field broadening every year.

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TELEPHONE ENGINEERING.

Erecting Poles.

BY F. J. DOMMERQUE.

Before the poles can be hauled away from the pole yard, the line must be laid out and every point where a pole is to be placed, staked off. The proper authorities must be asked for a permit to do the work, and the consent of the property owners obtained. In asking for a permit, the work to be done should be thoroughly detailed in order to avoid misunderstandings and to save trouble afterwards. In villages and small towns, it is good policy to ask the city or village commissioner to be present when determining the location of the poles, so as to have his approval before beginning work.

An application for a permit should be accompanied by a sketch, or still better, two sketches, drawn to scale, say 1 to 300 feet, and the poles should be properly marked thereon. The simplest way is to make a tracing from the real estate map or atlas, the tracing not being larger than the ordinary letterhead upon which the application is made. Three blueprints are made from this tracing, two to go with the application and one for file; the poles to be erected to be indicated on the tracing by a heavy black dot which will show white upon the blueprint. If poles of different descriptions are to be erected, as, for instance, line poles, anchor poles and guy poles, or if any combination poles (poles carrying besides the company's wires foreign wires, such as city fire alarm wires) are to be included, the white dots on the blueprint can be filled in with various colors in order to distinguish between the different kinds, and a key added upon the drawing giving the meaning of the various colors. If a permit is required for replacing an old line by a new one, it is best to show both pole lines, designating the poles to be taken down by a cross and the new ones by dots. It is essential to be explicit in permits, and too much should not be crowded on one drawing; it is better to take out several permits so as not to cover more than one street upon one sheet. The scale and the date must be put on the drawing, also an arrow pointing north and marked "N."

Poles are to be set in streets outside of the curb lines, so that the side of the pole clears the curbstone. Along country roads, the poles are set just outside of the abutting property. In alleys, they are set close to the building line. In streets where curbstones are already in, it is easy to locate the position of the poles by stepping off the distances, allowing a yard to a good-sized step. This primitive method of measuring distances is admissible as the poles cannot, as a rule, be set where they would come if the distances were measured with the tape line, because rights of the property owner must be respected; it has become a matter of common practice to locate poles at the division line of two adjacent pieces of property when possible, but if this cannot be done on account of the intervals between poles becoming too great, a place should be selected where the least disfigurement is caused to the property. The best policy, however, is to keep entirely off the streets and build in alleys.

Wherever possible, the location of each pole should be marked by a stake. On paved streets or alleys this is not always feasible, and in such cases a mark may be made with chalk, or still better, scratched with a hatchet on the curbstone or upon the rear of barns or fences. In the outskirts of cities, and also in new residence districts, very often no curbstones are found, nor are streets and sidewalks properly defined. In such cases, a surveying instrument should be used to locate the curb line according to information obtained from the city records. It is never safe to depend upon isolated houses built along such a street for location, and measurements should always be based in such cases upon the government monuments located on section-line crossings, where usually a round iron bar is found driven into the ground. The surveyor who regularly attends to locating the curb lines will soon become familiar with the location of these monuments. The surveyor should take with him a man to hold the rod and drive the stakes, which are cut about 18 ins. long and 1½ ins. square and pointed at the lower end; the driving tool is a lineman's broad hatchet.

The width of city streets is usually either 66, 80 or 100 feet. A 66-ft. street has a 14-ft. sidewalk, leaving a 38-ft. roadway; an 80-ft. street has a 16-ft. sidewalk and 48-ft. roadway, and a 100-ft. street has a 20-ft. sidewalk and a 60-ft. roadway; thus, the curb line is 19, 24 or 40 feet to the side of the monument. The curb line should be located from two monuments so as to obtain two distant points, and the two points should be established by driving two nails into the ground; over one nail the surveying instrument is placed and levelled so that the plumb-bob just touches the center of the nail's head. The rod is set upon the other nail so as to have the straight line in sight; back sight may be used to extend the line beyond the monument near which the instrument stands. Stakes are then set along this line at suitable points.

Poles should be set at a distance from each other of from 100 to 140 feet, as circumstances may permit. When severe strains are likely to be encountered, or the soil is loose, the distance should not exceed 120 feet, possibly be kept down to 110 feet; on large open areas where the wind has full sweep, poles should be set within 100 feet of each other, more especially in sections where wet snow and sleet storms prevail in winter. Under ordinary conditions, 44 poles are set to the mile, giving a distance of 120 feet between poles; on country lines, under ordinary circumstances, there is no objection to making the distance between poles 125 feet and over.

As soon as the line is properly staked off, the hauling of the poles may begin. The straightest, smoothest and best looking poles should be unloaded in front of residences and prominent buildings, and the heaviest and strongest poles at points where the course deflects from a straight line and at corners where the strain is likely to be excessive. The time between the delivery and erection of poles should be made as short as possible, as at night-time accidents are liable to occur by people stumbling over the poles. In cities, it is almost absolutely necessary to have poles set before the night of the day they have been unloaded.

Simultaneously with the distribution of the poles, the holes may be dug. The holes are dug close to the curbstones in streets, the curbstone serving as one wall of the hole, close to the barns and fences in alleys, and close to the abutting property lines on country roads. The holes should be dug to the following depths:

L'gth of pole.	On st'ght lines.	On curves.
25 feet	5 feet	5½ feet
30 feet	5 feet	5½ feet
35 feet	5 feet	5½ feet
40 feet	6 feet	6½ feet
45 feet	6½ feet	7 feet
50 feet	6½ feet	7 feet

The depth of holes for corner poles and wherever there is likely to be severe strains should be the same as on curves. All holes should be dug large enough to admit the poles without stabbing or hewing; if the holes are six inches larger than the butt end of the pole, that will be sufficient for the free use of the tamping bars. Care should be taken to have the holes full size at the bottom.

While the poles are being set straight they must also be turned around so as to bring the gains for the crossarms into proper position. Poles should be set so that gains face each other alternately on straight lines so as to prevent the pole line from coming down if one pole should break; if the crossarms pointed all one way, the pull of the wires in case of one pole breaking would tear the crossarms off the other poles. On curves, however, the gains should all face toward the center of the curve, and on terminal poles and on long lines, the gains on the last two poles should face outward. At road and any other crossings, the gains should be placed on the side of the pole facing the crossing.

There are many cases where the condition of the soil is such as to offer insufficient resistance against the forces acting upon the poles. The soil may be sandy, quicksand predominating over part of or the entire route or the pole line may pass through a swampy or boggy district. In such cases, the following methods are best adapted to the respective situations. In all such cases, the pole holes should be dug wider and at least six inches deeper than usual. In sandy soil it is customary to use a so-called sand barrel, for which may be used an ordinary barrel having its top and bottom taken out. This barrel is driven into the hole and the pole is set within the barrel and braced with pike poles; after which the barrel may be withdrawn by breaking it to pieces, or it may be left in the ground. In the latter event, the space between the barrel and the pole is filled with clay carefully and firmly tamped down, always piling the clay around the pole from 18 to 24 inches above the surface of the ground; or the space may be filled with concrete consisting of one part cement, two parts of sand and five parts of stone. Some of the packing is allowed to slip under the pole to prevent it from sinking. If the barrel is withdrawn, small rocks and stone should be driven by tampers into the sand which has flowed in around the pole until no more can be forced down. Telephone companies with much quicksand in their territory frequently use iron sand barrels made in two halves and hinged together. Such a barrel is let into the hole by a fall and tackle and when the pole is set the barrel is hoisted up, the hinges are opened and it is removed from the pole.

In moist and boggy soil, the space between the sides of the hole and the pole may be filled with broken rock well tamped down and the rock again piled around the pole at least two feet above the surface of the ground; or better still, the pole is set in a bed of concrete at least 18 inches thick and a pair of key-blocks, 2 ins. x 10 ins. x 12 ins., bolted to the pole on alternate sides of its base, one block being bolted to the pole at a point 12 inches below the surface of the ground and the other block 6 inches above the butt, the blocks being parallel with the crossarms. It should be the rule to let the pole rest on a footplate whenever soft or treacherous soil is encountered, this footplate to consist of two planks from one to two inches thick and at least 12 inches wide and 24 inches long, and crossed under the foot of the pole. The harder the wood of which they are made the better. For guy and anchor poles a complete framework is built to secure the stability of the poles. A description of this will be given later.

When building pole lines on the side of a high hill or down into a deep ravine, it is advisable to use poles of different lengths in order to avoid abrupt changes in wire levels. In building a line parallel to or near railroad tracks, the poles should be set at a distance from the nearest rail of not less than 12 feet. Before attempting to cross railroad tracks, a permit should be secured in writing from the proper railroad officials on an application showing the proposed essential features of construction at that point. At all railway crossings the poles should be high enough to insure a distance of at least 22 feet between the top of the rails and the lowest point to which the lowest wire may sag. At such crossings, the wires should be dead-ended on each side of the crossing and a short piece of wire connected into each end of the gap of sufficient length to bridge the space intervening from the pole on one side of the tracks to the pole on the opposite side. Double-grooved pony insulators are best used at such crossings. When there are ten or more wires it is advisable to use a lead covered aerial cable.

At the crossings of country roads poles should be high enough to insure a distance of at least 18 feet between the crown of the road and the lowest point to which the lowest wire may sag. Within the limits of incorporated boroughs and towns, poles should be used that will insure a distance of at least 20 feet between the crown of the roadway and the lowest point to which the lowest wire may sag.

In crossing other telephone lines, poles should be used that will insure at least 4 feet in the clear between the tops of the poles of the line crossed and the bottom of the lowest gain on the poles set to support the crossing wires.

Crossing an electric light or street railway line should be avoided if possible. However, where it cannot be done, there should be at least 4 feet of space between the uppermost electric light wire, which is in such cases always insulated, and the lowest gain on the telephone poles. Trolley wires will always be considerably lower than the lowest gain on the telephone pole, but there must always be guard wires drawn underneath the telephone wires at the crossing in such a manner as to prevent any telephone wire when broken from falling upon the trolley wire.

When the poles are firmly set, the work of putting on the crossarms begins. The gains must have been covered thoroughly with two coats of white lead and the crossarms loaded on a wagon, which proceeds along the line either delivering the crossarms at each pole or remaining with the crossarming gang dealing out crossarms as needed, usually the former. In many cases the uppermost crossarm is already attached to the pole before setting. When this is the case, the next crossarm is most conveniently hoisted up with a rope by a lineman seated upon the crossarm already in place. The braces and pins are attached to the arms before hoisting. The method of fastening the crossarms to the pole has been already described. Where pole-steps are used, they may be put on before the crossarms, and where protection strips and butt-guards are required they should be attached before painting.

RELATIVE ADVANTAGES OF ELECTRICAL AND MECHANICAL METHODS OF VARIABLE SPEED CONTROL FOR GENERAL POWER SERVICE.

BY WILLIAM COOPER.

The expression "variable speed control" is ordinarily understood to mean a system whereby a machine, or other piece of apparatus, can be operated at any one of a number of predetermined speeds, and when set to operate at any one of those speeds, will continue to operate at that speed regardless of any change of load, or other operating condition. This definition is evidently too narrow, as there are numerous methods of variable speed control that, while not absolute, are sufficient for the purpose to which they are applied. It might be said that a series-wound, direct-current motor, operating a hoist, as on a crane, constitutes a method of variable speed control. The operator has absolute control of the speed and can operate at almost any speed within certain limits. However, any one position of the controlling handle does not necessarily give any particular speed, and any change of load changes the speed.

The expression, "variable speed control," is capable of three general definitions: (1) Where the speed is variable at the will of the operator, and remains constant when once adjusted, regardless of any change of load or other operating conditions; (2) where the speed is variable at the will of the operator, and may or may not remain constant, depending upon the conditions of operation; (3) where the speed is variable according to some prearranged plan, and is controlled automatically by some inherent property of the apparatus or of the driving power. It is assumed that the prime moving force, or power, is constant and uniform in every case. That is, if a mechanical method of variable speed control be used, the shaft from which the power is taken rotates at a uniform velocity. If an electrical method of variable speed control be used, the energy is supplied at uniform pressure and frequency. It is also assumed that the mechanism and apparatus used in connection with any method fulfills its functions properly, and does not, for instance, come under the second definition when intended to fulfill the requirements of the first. A mechanical method that depended upon friction for its action would do this if it should slip. A shunt-wound direct-current motor, with abnormal resistance in its armature circuit, would also do this.

In classifying the different kinds of apparatus in accordance with the foregoing definitions, there are found to be some methods that come within more than one definition. For instance, in the operation of direct-current, series-wound motors, the action, so far as the operator is concerned, is in accordance with the second definition, while, from the designer's standpoint, the action is in accordance with the third definition.

A general classification, however, would be that mechanical methods come within the first and third definitions; the electrical methods coming within these definitions and holding undisputed possession of the second.

In classifying the different kinds of mechanical and electrical apparatus, they fall under the different definitions about as follows:

First Definition—All methods of mechanical variable speed control, except those used in connection with automatic machinery, come within this definition. The most common method of mechanical variable speed control is the use of the step-cone pulley. Next in point of common use is the use of change gears. Next, change gears in combination with step-cone pulleys. These arrangements are not only the most common, but they constitute probably ninety per cent. of all the speed-changing apparatus now in use.

Several devices have been used to some extent which are modifications of these step cones and change gears. In some the cones are used, but the steps have been eliminated, and two reversed truncated cones is the result. These are driven either by a belt passing around the two cones as an ordinary belt would be used, or by a loose belt around one of them, this belt being pressed between the two cones by suitable or unsuitable screws or levers. In either case the belt is moved lengthwise of the cones to vary the velocity ratio of the two cones. This arrangement is the natural outgrowth of the step-cone method, and has the advantage over the step cone of requiring much less time for adjustment and being capable of giving any speed within its range. As an outgrowth of the gear method, there are numerous methods of using clutches, and other ways of getting them in and out of gear. Another method of belt drive consists in using a heavy belt running in grooved pulleys the relative diameters of which can be changed at will. Almost every conceivable arrangement of gears, belts and friction wheels have been used to accomplish this result, some of which have merit and utility, while others are little better than mechanical monstrosities.

The electrical methods that come within this definition are not nearly as numerous as the mechanical, and consist in the use of only one type of motor—the shunt-wound, direct-current motor. There are, however, several ways of operating the motor to give the desired result.

There are three ways of changing the speed of a direct-current motor; first, by changing the e.m.f. impressed upon its armature; second, by changing the strength of its field; third, by changing the number of conductors in series from brush to brush on its armature. The impressed e.m.f. can be changed in two ways: by connecting the armature to circuits of different voltages, or by inserting a resistance, which may be varied, in the armature circuit. The number of conductors in series on the armature can be changed in several ways. The simplest, and the only one that is used to any extent in practice, is to use two commutators and two separate windings on the armature. These two windings can be connected in series, and if they are identical, they may be also connected in parallel. The series arrangement gives practically one-half the speed of the parallel arrangement. The windings need not, however, have the same number of turns, in which case they may be operated in series for one speed and separately for two other higher speeds. This arrangement of two commutators is very useful where only a few motors are to be installed, but if the number exceeds five or possibly ten, there are other methods that are much simpler and more effective. The field magnetism can be changed in a shunt-wound motor by inserting resistance in the field circuit, and in a series-wound motor by shunting a portion of the current by a resistance in parallel with the field windings.

Any of these methods of changing the speed of a shunt-wound direct-current motor can be used, and come within the limits of the first definition, except that of inserting resistance in the armature circuit. It would then come under the second definition.

Second Definition—There are, from the very nature of the case, no mechanical methods that come within this definition. The series-wound direct-current motor, that holds the street-car and traction field against all comers, that does practically all of the crane and hoisting work, the motor of motors for hard work, comes under this definition. The shunt-wound, direct-current motor, when controlled by resistance in the armature circuit, also comes under this definition, as well as all direct-current motors that are combinations of series and shunt.

Third Definition—There are many mechanical devices within this class, used mostly in connection with automatic machinery of various kinds. The mechanical device may operate clutches, or may act upon the controller of the driving motor, if the apparatus be driven by an electric motor. These various arrangements are all in the nature of special apparatus, and do not directly enter into this comparison. There is, however, one electrical method that comes under this definition that is of great value in many kinds of work. The series-wound, direct-current motor has an inherent property of varying its speed in inverse proportion to the amount of work it is called upon to do. This property is made use of in the design of motors for street railway and traction purposes. For instance, suppose that it requires 50 horse power to propel a given car at 30 miles an hour on a level track. Assume that the tractive effort required, under these conditions, be 10 pounds per ton, the car would weigh, approximately, sixty-three tons. If this car be required to mount a 10 per cent. grade, the tractive effort required will be 210 pounds per ton; 200 pounds for the grade and 10 pounds for friction, etc. Now, if a constant speed motor be used, it would be required to develop 1,050 horsepower to drive the car up the 10 per cent grade. Assume that, due to the inherent regulation of the motor, the speed falls to 10 miles per hour, then the motor will only be required to develop approximately one-third the horse-power, or 350 horse-power. In practice this condition would not require a motor of 350 horse-power, normal rating, neither could one as small as 50 horse-power be used, but a mean somewhere between the two, depending upon what part of the total time the car would be mounting 10 per cent. grades. It is obvious, however, that there would be an enormous difference in size between the two motors.

Each case where variable speeds are desirable must necessarily be considered by itself, as to whether the method to be adopted will come under the first, second or third definition. The first definition covers the most general application, although there are many cases where absolute limitations of unvarying speed are not necessary, or where changing load or operating conditions can be met by manipulation of the controlling device. It is, however, necessary to use a method that will produce the result set forth in the first definition where constant speed is desired, and the torque, or turning moment required, changes to any considerable amount. Included in this class are practically all machine tools; such as engine lathes, drill presses, slotters, shapers, planers, boring mills, and all machines, which work intermittently, or where the operation is started with the machine in motion. All wood-working machinery also comes within this class. Blowers and pumps, when operating with a constant discharge per revolution, and the discharge per unit of time is to be regulated by varying the speed, do not necessarily come in this class, and can be operated by any system, as the torque remains constant. Printing presses constitute another large class of machinery in which variable speeds are required, but in most cases, except in the larger sizes, the conditions are not very exacting, and can usually be met by methods within the second definition.

ADVANTAGES AND DISADVANTAGES.

Aside from, and not a direct function of the variable speed part of the proposition, might be mentioned some of the advantages and disadvantages of electrical and mechanical drive in general. A mechanical drive, be it variable or not, in general means belts; belts mean dust and dirt deposited on walls and ceiling; dust and dirt on walls and ceiling mean a dark room, and less work. An electrically-driven machine causes none of this trouble. In the selection of the method of drive, too little attention is given to this point.

In comparing the electrical and mechanical methods strictly on a basis of speed variation, the comparison might be divided about as follows:

First—Total number of speeds within the range; second—ease of manipulation; third—cost of maintenance; fourth—total range of variation obtainable; fifth—time required to cover entire range; sixth—portability of machine; seventh—space occupied; eighth—cost of equipment; ninth—constancy of speed at any position of controlling mechanism, and tenth—efficiency. In explanation of this classification, it might be said that the points are drawn out in what might seem to be useless detail, because they are all important, and must each be given due consideration. It will be noted that the point of efficiency is placed last, also that the cost of equipment is well toward the last. The number of speeds within the range of variation, or the amount of the change between two steps, has been placed first in the list as being of greatest importance. This means the ability to get an exact speed that is best fitted for the work to be performed. If it is desirable to have any system of variable speed control, it is evident that it is for the purpose of getting different speeds. And if different speeds are required, they should be obtained with great exactness.

In comparing the different mechanical and electrical methods, it is found that there are two distinct classes of mechanical devices. One class is composed of those methods where a change from maximum to minimum is made gradually and gives an infinite number of speeds between the two extremes. Another class is where the changes are made in steps, as in the use of step-cone pulleys and change gears. The first class stands alone, as the perfect speed-changing device. Even an electric motor cannot be made to give the same great number of different speeds, for the reason that a motor must be regulated by steps, although it is a very simple matter to make this number quite large and sufficient to meet the most exacting conditions. Step-cone pulleys and change-gear arrangements, when carried to the point of yielding the same number of different speeds, become very complicated. While it is entirely possible to get a change in this manner of 10 per cent per step, the complications resulting from the mass of gears and multiplication of steps on the cone pulley would not be permissible, to say nothing of the time lost in making the changes. As a result of years of practice, this system has developed into an arrangement where the changes are approximately 50 per cent per step; that is to say, each increment of increase is 50 per cent; often as much as 100 per cent. It is obvious that such an arrangement must be very wasteful of time, as it will often occur that the work in hand will not quite permit of a certain combination, and must necessarily be run at the next lower speed, consuming more time for a given operation than would otherwise be required.

There is also another fact that should not be lost sight of in this connection. The range of speeds given by the step cones on a great many machines is not consistent with the ratio of the back-gearing used. That is to say, it is frequently found that the difference between the lowest speed with the back gears out and the highest speed with the back gears in, is very much greater than the difference between two cone speeds. Some machines have as much as three-to-one variation in speed between these two conditions. As a case in hand, might be mentioned a comparatively small-sized boring mill, made by a prominent manufacturer, in which the back-gear ratio was twelve and one-half to one. Assuming that the cone speeds were consistent with this back-gear ratio, the average difference in speeds throughout the entire range would be about one and nine-tenths to one, the machine being equipped with a four-step cone. This is certainly a very crude solution of the problem of variable speed control, and yet there are thousands of machines no better than this in everyday operation in manufacturing establishments, where they are supposed to be running things to the limit, and on the most economical basis. The crudest kind of apparatus that would subdivide the speeds of such a machine would certainly produce superior results.

Ease of manipulation in the apparatus used should be well considered. If the device requires considerable manual effort on the part of the operator to effect the changes, there is much less liability of a change being made when the nature of the work really demands it. A great deal can be sacrificed in other directions to relieve the operator of all possible manual effort, not alone because of the natural inclination of a man to do as little manual work as possible, but because in most cases where a device of this nature is used, the operator is paid for his skill and the use of his brains and not for his manual effort.

It also, as a rule, follows that a device that requires any considerable amount of effort to operate will also consume considerable time. All of that class of devices that use change-gears and step-cone pulleys require more or less manual effort, especially where friction clutches are used to throw them in and out of gear. The electrical method probably offers the easiest operation, as a simple movement of the controller handle not only gives the different speeds, but also stops, starts and reverses the motion of the machine.

Cost of maintenance should also be given due consideration. Generally speaking, the piece of apparatus that has the smallest number of moving parts will be the most durable, and an effort should be made to eliminate all parts possible. Most mechanical speed-changing devices that fulfill the requirements and are worthy of the name of speed-changing devices are quite complicated, and embody in their structure a great many parts that are subject to a great deal of wear. The modern electric motor, without doubt, requires less attention for repairs than any other piece of apparatus that would fulfill the same functions.

In considering the installation of a method of variable speed control, the total range of variation is one of the first problems to be solved. The machine to which the device is to be applied calls for certain maximum and minimum speeds, these maximum and minimum speeds, of course, being determined by the work that the machine is intended to perform. With the exception of such machines as are operated day in and day out on one particular and specific operation, almost any machine used in manufacturing, or in an industry of any kind, could be worked to advantage at different speeds. For instance, the simple operation of calendering paper can be done to much greater advantage if the speed can be adjusted to the quality of the paper being handled. In this case a comparatively narrow range of speed would be required. In the operation of printing presses this condition also exists. In a great many machines used in the manufacture of boots and shoes the same condition exists. In fact, there are thousands of cases where a method of variable speed control could be used at a profit, where uniform speed is now considered good enough.

The class of machinery that probably requires the widest range of variable speed, comprises machine tools; especially is this true of that class of machine tools that operate upon cylindrical work. In all the different methods of variable speed control, when applied to machine tools, recourse is generally had to some arrangement of gearing. An electric motor would be out of all proportion if designed to cover the wide range of speed variation called for in an ordinary engine lathe.

The total speed range of machine tools that operate on cylindrical work should not be less than sixty to one, although in some special cases a very much narrower range than this will suffice. In equipping such a machine with an electrical method of variable speed control, if an attempt is made to cover this entire range inherently within the motor, the motor would be abnormally large and expensive, although it is possible to do this. The use, however, of one set of gears in connection with the machine simplifies the proposition very materially. In the class of machine-shop tools in which the work has a constant relative motion to the cutting tool—as in planers, slotters and this class of machines—and speed variation is only required for different kinds of material, the total range can be easily covered by the mechanical devices in use, or by the inherent speed regulation of an electric motor.

If the range of variation of the method employed necessitates the use of one set of back gears in order to make the method practically operative, the question will naturally arise, why not use two or more sets and still further simplify the speed-changing device, or reduce the size of the variable-speed motor? Duplicating the gearing indefinitely until variations in speed are entirely taken care of in the gearing, brings us to a mechanical speed-changing device pure and simple, in which the changes are all brought about by different combinations of gearing. The use of one pair of gears is objectionable because of time consumed in the manipulation, and also because of the wear and tear; consequently, a multiplication of gearing multiplies these objections.

The advantages of having any machine entirely independent and portable are too well known to need much illustration. It enables one to locate the machines in the best possible position for the facility of handling material, and if at any time the process is changed, the machinery can be readily changed to suit. The machines can be placed under traveling cranes in such a position that they can be served to the best possible advantage. It often occurs that some simple operation is required on a large amount of material, in which case the machines can be taken bodily to the work at a very much less expenditure of time and labor than would be required to bring the material to the machine. The advantages gained by the portability of machines makes a direct comparison of the electric drive with any mechanical system of drive very difficult, as no mechanical system can be said to embody this feature in the slightest degree.

In equipping a new plant or factory of any kind, a careful summation of all the costs in connection with the different systems will show that there is but little actual difference in the total first cost. In the individual application of motors to machinery, the cost of the motor and its accessories increases the cost of the individual machine very materially, but when the decreased cost of the building, owing to the absence of heavy lines of shafting, is taken into consideration, a very material offset is found. When compared with the actual cost of the installations of the mechanical speed-controlling mechanism, a still further offset in the cost is found.

In equipping old machinery with variable-speed-controlling devices the proposition is somewhat different. The investment for transmitting power to the machinery has been made, the building has been constructed with a view to carrying the necessary line shafting, countershafting, etc., and this has all been installed. The proposition of a very much increased investment at once confronts the would-be purchaser, if he considers the installation of individual electric drive. He naturally turns his attention to the mechanical methods of variable speed control, and finds that he can install some of these systems at a very much less cost. In justice to the mechanical systems of variable speed control *that fulfill the requirements*, it must be said that under these conditions they certainly accomplish the results sought. However, considerable expense is involved in the installation of such a device, and usually an increased cost of operation. These points should be given due consideration in comparison with the radical changes to individual electrical drive.

The electric motor is to most people operating manufacturing plants and establishments of different kinds, a rather mysterious thing. This, coupled with the poor behavior of some motors that they may have come in contact with, has caused them no little apprehension and doubt as to the capabilities and durability of the modern electric motor. This condition of affairs has made it a good deal in the nature of "buying a pig in a bag," to the average purchaser, and it must be admitted that in a good many cases this was actually the fact. The modern electric motor, however, has developed into a reliable machine, to be depended upon for hard work and faithful service; and although the cost may seem considerable when compared with some other systems of operation, when all the facts are taken into consideration, the first cost of a new installation is not materially different.

The only mechanical methods of variable speed control that are really worthy of consideration are those in which any number of different speeds may be obtained, and, from the very nature of the case, some form of friction drive must be used. This may be a belt drive, or one of the many kinds of friction-wheel arrangements. These friction arrangements are at best not thoroughly reliable and consume considerable power in their operation. On the other hand, an electric motor, when used as a variable-speed device, has one drawback; the speed is not absolutely constant, due to the "drop" in the armature, by virtue of the resistance. This characteristic when the motor is used on very low voltages, makes the inherent regulation from no load to full load in some cases very poor. This point should be well guarded against in the design of motors for this service. A motor used to operate an engine lathe, for instance, which will drop twenty-five or fifty per cent. in speed when the tool is applied to the work, will not give satisfactory results. Neither will a mechanical device that has a propensity for slipping whenever called upon to do hard work give satisfactory results. Any device used for the purpose of variable speed control should be able to drive the machine to which it is applied under any and all conditions, from the very lightest to the very heaviest work that it may be called upon to do, without showing a variation in speed of more than a few per cent. A great many arrangements for variable speed control have proven entirely unsatisfactory for this reason. Many attempts have been made to operate machine tools with motors where the speed regulation was obtained by resistance in the armature circuit. These, without exception, have proven failures. There are some instances, however, where a small amount of resistance is used in the armature circuit in connection with multi-voltage systems of control that have not proven failures, but the results obtained are not what they should be, although the general result of these applications may have been satisfactory.

A comparison of the efficiencies of the various mechanical methods of speed control with the various systems of electrical speed control is not altogether favorable to the mechanical system. An electric system, even when using very small motors individually applied to very small machinery, will show a better efficiency from the prime mover to the work than any mechanical system of power distribution, except in cases where the number of machines driven is very small, and the power from the prime mover is applied directly to the machines. Of course, due consideration must be given to the size and type of the motor installed, when using the electric system for power distribution, due regard being had for the average working conditions. The reason that the electric systems of power distribution, in case of individual motor application, show higher total efficiencies, is, of course, that when no work is being done, no power is consumed; while with the mechanical system of power distribution, there is always a friction load. It is not at all uncommon for the friction load of a manufacturing establishment to be 50 per cent of the maximum load on the prime mover. In an electric system of power distribution, the conditions would be very bad indeed if the power factor were not higher than this.

CONCLUSIONS.

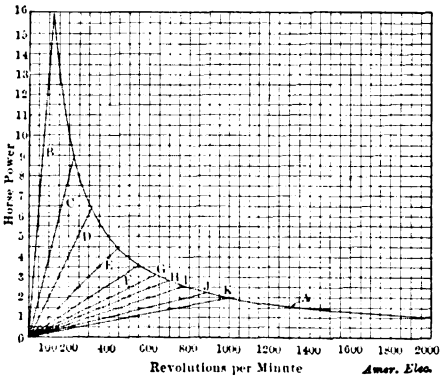
In the installation of a new manufacturing plant in which machinery will be installed that will require to be operated at varying speeds, the methods employed should be considered in about the following order: First—what system will assist in yielding a maximum output from the machinery installed; second—the comparative costs of the different methods installed. Mr. L. R. Pomeroy, in a paper read before the Central Railway Club, in Buffalo, November 14th, last, quoted a celebrated authority as follows: "Where we have to decide whether we shall install one large motor or a number of small ones, I would give preference to the small motors down to a limit of five horse-power for light machines, and ten horse-power for heavy machines; this for cases in which the problem is one of distribution only. Where the introduction of motors would have any effect on the product, I would dismiss entirely the question of power and decide solely with regard to the convenience of operation afforded, and would not hesitate to put in the very smallest motors mounted upon any kind of machinery, notwithstanding their greater cost and lower efficiency, if they even to but a slight degree increase the product of the labor of the shop. Gains in this direction cause other gains to sink into insignificance."

In this comparison, the authority quoted is only comparing small motors with large ones in the point of efficiency. The point of this remark is that any gain in the increase of the production of the labor of the plant is of more importance than any other consideration. It is a very simple matter to calculate how much the production will have to be increased to offset a given investment. When this calculation is made it is easily seen that a very slight increase in the production will offset a very large investment.

When an attempt is made, however, to make an exact determination of the increase in the production, due to the installation of any important apparatus, it is found to be a very difficult thing to do. The introduction of a traveling crane into a plant handling even comparatively light material, is always accompanied by an increase in the output, although the labor item may not be very materially reduced. The reason for this is not hard to find. Although the same number of men may be employed on a given floor space, the amount of material that these men can handle is increased for the simple reason that only a certain amount of crowding of workmen or machinery into a given space is permissible. The same thing is true of the introduction of apparatus that will hasten the production of the machines themselves.

Usually, in the consideration of the advisability of installing any certain method of operation, the questions are considered in the reverse order to that given above. The first question is "How much will it cost?" when really the first question ought to be "How much will it increase the output?"

Great care should be exercised in the selection of motors for different machines to determine whether the horse-power required is practically constant or varies with the speed. In most machines of a reciprocating action—slotters, shapers, planers, etc. —the power required varies with the speed, as the power is consumed in the reversals of the machines, and not in the actual work being done. In cases of this kind, the motor will be called upon to do its maximum work at the maximum speed of the machine, while in the case of machines in which the work performed is constant, irrespective of the actual speed of the machine itself, the power required to drive it will be practically constant throughout the entire range of variation. In machine-shop tools such as lathes, boring mills, milling machines, etc., this condition exists.



Amer. Elec.

FIG. I.

When the range of different voltages impressed upon the armature of the motor and the range through which its speed is changed by changing the amount of magnetism in its field, are properly proportioned, the minimum-sized motor for a given total speed variation is obtained. This can readily be seen from the curve in Fig. I. In explanation of the use of the curve in any given instance: if the speed range has been determined—as well as the maximum and minimum speeds—the full field full-speed voltage can be ascertained from the curve as follows: Locate on the curve *A* the point corresponding to the maximum speed which it is desired to operate. Trace to the left from this point to the marginal scale and read the horse-power. This horse-power may not be the actual horse-power in any given case, but it can be assumed as proportional to the actual horse-power required. Again trace from the minimum speed, which it is desired to operate, vertically, until the horzontal line which represents the same horse-power that was determined from the curve *A* is reached. Through this point draw a straight line from the origin *O*, intersecting the curve *A*. From this point of intersection trace downward to the base line and the full voltage, full field speed of the motor will be found.

To get the minimum speed we must use some other method than field control, because the field is already up to its maximum strength, and we therefore introduce a lower voltage. The ratio that this lower voltage bears to the normal voltage is the same as that which the lower speed bears to the normal speed. By this combination of multi-voltage and field control we are able to use the minimum size of motor for the given work.

The following few simple rules may be of use in determining the relative size of motors for constant horse-power application:

First—The total range of speed, using both variable voltage and field regulation, will be as the square of the range of voltages.

Second—The change in horse-power will be directly proportional to change of voltage impressed on the armature, the field being constant.

Third—The change in horse-power by change of field strength will be inversely proportional to the change in speed, the voltage on the armature remaining constant.

Fourth—The relative size of the motor, as referred to the maximum speed, will be directly proportional to its speed variation, when using variable voltages.

Fifth—The relative size of the motor, as referred to the maximum speed, will be as the square of the speed variation when using field regulation.

[The foregoing is a paper read at the Chicago convention of the National Electric Light Association.]

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Recipes for Soft Solder.—A writer in the *Metal Worker* gives the following as good recipes for soft solder: A good soft solder is composed of 50 parts bismuth, 25 parts tin and 25 parts lead. This mixture melts at 200 degrees F. Another good solder is composed of 50 parts bismuth, 30 parts lead and 20 parts tin. This will melt at 190 degrees F. The solder that is used in soldering Britannia metal and block tin pipes is composed of two parts tin and one part lead. This melts in the blow pipe flame at many degrees lower temperature than either tin or Britannia metal, and it is nearly of the same color. Care must be taken in mixing these solders to keep them well stirred when pouring into moulds. Care should also be taken that metal which melts at a higher temperature be melted first and then allowed to cool to the melting temperature of the next metal to be added, and so on. Articles to be soldered with these solders should be joined with a blow pipe to get the best results, but if a copper is used it must be drawn out to a long, thin point. For a flux use powdered rosin or sweet oil.

Convention of the National Electric Light Association

The twenty-sixth annual convention of the National Electric Light Association was held at the Auditorium Hotel, Chicago, assembling on May 26 and adjourning, *sine die*, on the 28th. The convention was called to order by President Louis A. Ferguson, of Chicago, on the morning of the 26th, when resolutions passed by the City Council of Chicago, welcoming the delegates and extending to them the freedom of the city, were read. On motion of Mr. Insull, a suitable acknowledgement of the resolutions was sent to Mayor Harrison, who was deterred from welcoming the delegates on account of pressing engagements. Mr. Ferguson's presidential address was then delivered. In it, the president referred to the great increase in the membership of the association, there being now 452 active, 80 associate, and 26 honorary members. It had been customary in opening the convention for the president to review the development of the art through the year, but this year a departure from this custom was made. At the previous convention, there had been considerable discussion on the subject of the relation between manufacturers and central station companies, and the president was pleased to report that through personal efforts on the part of the association, in taking up with the manufacturer's individual cases as they arose, a willingness was manifested on the part of the manufacturers to co-operate with the association to all reasonable extent. Several cases of unfair competition had been successfully handled, and in no instances where assistance was requested had the association failed to protect the interests of its member companies.

The committee on standard rules for electrical construction and operation had been unusually active during the year with work in connection with the National Electric Code. Certain changes in the rules for overhead construction had been proposed by the committee of the National Underwriters' Association and were under consideration by a committee representing the American Institute of Electrical Engineers. President Ferguson, feeling that many of the proposed changes in the rules were impracticable and unfair to the member companies of the association, communicated with the president of the American Institute of Electrical Engineers, urging a postponement of favorable action on these changes until they could be considered by the National Electric Light Association The request was granted and the committee on standard rules invited to attend the joint meeting of the committees of the National Underwriters' Electrical Association and of the American Institute of Electrical Engineers. At the two meetings of the joint committees held in Boston, the committee and the president were in attendance and took an active part.. The position was taken that no changes could be made in the rules for overhead construction without a meeting of the conference consisting of representatives of all associations interested in the subject. After considerable argument the association was sustained in its position, and as a result of the efforts of the committee, assisted by a committee of the Association of Edison Lamp Companies and the American Institute of Electrical Engineers, the Underwriters removed many of the objectionable features in the proposed changes of the rules.

President Ferguson said that the re-establishment of a conference, after an inactivity of five years or more, to finally pass upon all rules of the National Electric Code was of prime importance to central station companies and prevented the establishment of rules by the Underwriters which might seriously injure the electrical interests of the country and retard the development of the industry. The necessity for closer relations with other associations of kindred character was shown by the joint committees of the National Electric Light Association and the Association of Edison Lamp Companies in the matter of the National Electric Code. The president stated that while the American Institute of Electrical Engineers, as a purely technical society, might formulate rules, or the National Bureau of Standards adopt standards of measurement, both of which from a purely scientific standpoint might appear good, still these might be deleterious from the business standpoint of the members of the association.

CHARLES L. EDGAR,
President National Electric Light Association.

The president urged the appointing of a committee of three good mechanical engineers to follow the development of the steam turbine through the coming year and report the results at the next convention There is probably no piece of apparatus in the construction of the central station at the present time, the results of which, he said, were awaited with more interest by central station managers than the steam turbine. It seemed expedient, therefore that the association should not rest with the information given at the present convention. It was also important to central station companies, he continued, that the growing demand for electric power in factories should be considered and this business obtained for the central station. Statistics showing the useful and economical application of electricity in factories, together with costs at various rates per kilowatt-hour, are not readily obtainable, and the president recommended the appointing of a committee of three men from different sections of the country to gather statistics on purchased electric power in factories, the committee to report at the next convention, or sooner if found feasible.

Mr. Dougherty moved that the president's address be referred to a committee of three for consideration. This committee, consisting of Mr. H. L. Dougherty, Madison, Wis., Mr. C. L. Edgar, Boston, and Mr. H. H. Fairbanks, Worcester, Mass., which made its report at the Thursday afternoon session, recommended the appointment of three engineers as suggested by the president and authorized the expenditure of a sum not exceeding one thousand dollars in the investigation of the subject. They also recommended the appointing of a committee to watch the movement of other kindred bodies and engineering societies, to confer with them from time to time and to promote a closer relationship with them, so that their actions might not be antagonistic to the members of the association. The committee also recommended the appointment of three members from various parts of the country to collect information and report to the association at its next meetin. They urged the continuation of a progress editor and the continuance of other reports on special subjects, also the continuation of the "Question Box" in its present form, which seemed to fill all the requirements and resulted in a saving of time. The report of the committee was adopted, and the special recommendations of the report were authorized.

Mr. Ernest H. Davis, of Williamsport, Pa., who had been appointed to fill the unexpired term of Secretary James B. Cahoon who was compelled to resign his office on account of ill-health, read letters of regret from the following gentlemen who were unable to attend the meeting.

C. F. Brush, Cleveland, Ohio; Prof. Elihu Thompson, Lynn, Mass.; Thomas A. Edison, Orange, N. J.; Carl Hering, Philadelphia; C. H. Mortimer, Secretary Canadian Electrical Association, Toronto, Can.; Prof. Edward L. Nichols, Ithaca, N. Y.; Prof. Henry T. Bovey, McGill University, Montreal, Can.; Prof. J. R. Angell, President University of Michigan; Prof. Henry S. Carhart, University of Michigan; Prof. E. A. Birge, President University of Wisconsin; Prof. S. P. Breckenridge, Professor of Mechanical Engineering, Urbana, Ill.: W. H. Merrill, Electrician, National Board of

Fire Underwriters, Chicago; C. M. Goddard, Secretary Underwriters' National Electric Association, New York; Ex-President, M. J. Francisco, Rutland, Vt.; William R. Harper, President University of Chicago; Prof. Harris J. Ryan, Cornell University, Ithaca, N. Y.; Ex-President Edwin R. Weeks, Kansas Citv, Mo.; Prof. A. E. Kennelly, Harvard University, Cambridge, Mass. and R. S. Kelsch, Montreal, Can. The report of the "Editor of Progress," Mr. T. C. Martin, of New York, was then read.

The Tuesday morning session was concluded with a report on "Office Methods and Accounting," by Mr. Walter M. Anthony, of Chicago. In the discussion of this report, Mr. Samuel Insull, president of the Chicago Edison Company, emphasized the absolute necessity of a thorough accounting system even in connection with the smallest electric light enterprises. One trouble with the majority of small companies was they did not know because of their defective accounting systems whether they were making or losing money. He had bought in a number of small electric light companies recently, and in no case were the accounts in an intelligible shape. In several cases he had been able to purchase these plants at a lower figure than would have been the case if their owners had maintained a system of accounts whereby they knew their financial condition definitely. In these cases, the absence of an accounting system had been beneficial to him personally; he, however, made the suggestion for the benefit of the companies

SECOND SESSION.

The second session was opened at two o'clock Tuesday afternoon, when Mr. Sidney Hosmer, of Boston, presented his paper on the "Advantages to be Derived from a Consolidation of Electric Interests." This was followed by a paper on

"Boiler and Furnace Efficiency."

by Mr. A. Bement, of Chicago, which is reprinted elsewhere in this issue. In the discussion of this paper: Mr. W. L. Abbott, of Chicago, said that the question of boiler and furnace efficiency had been his hobby for several years. He was convinced that this was the important end of the power station. Mr. Bement's paper, he said, brought out strongly the important fact that one did not always realize that a large proportion of the heating surface of a boiler may be lying dormant, and the remaining portion overworked to such an extent that a comparatively poor efficiency from the boiler was obtained. If all the heating surface of the boiler were brought into use one could utilize the boiler to a much greater capacity with the same efficiency. The following is an old illustration of this with a common return flue boiler: Stand a stick of dry pine inside of the smoke extension in front of the center row of flues, and let it remain a short time. That portion of the stick opposite the upper row of flues will be much charred, while that near the bottom flues will be scarcely charred at all, showing that the gases coming through the upper row of flues are hotter than those coming through the bottom flues. With a proper distribution of the draft, the gases would be made to travel through all the flues uniformly. The same thing applies to some types of water tube boilers. Gases are sure to take a short cut through the boiler in some way or other, and leave dead pockets. The method described in Mr. Bement's paper, he said, is an efficient preventive of smoke. During the past winter the Chicago Edison Company had burned coal under boilers fixed in this way, at a rate of three-fourths of a ton a minute under the stacks illustrated in Mr. Bement's paper, without producing the slightest cloud of smoke. There was no special care taken in firing to prevent smoke, but from the construction of the furnace it would take all the coal that could be given it, and burn it completely without smoke. The smoking stack shown in Mr. Bement's paper was over furnaces of different construction. Smoke, he said, will inevitably be produced if coal is burned in a furnace where the flames come in contact with the cold boiler surface before the combustion is complete.

Mr. Lieb cited some investigations and tests made several years ago in New York, when an estimate was made to determine to what extent it was admissible to force boilers using the steam sizes of hard coal. Something like 25 per cent of the total capacity of the plant was called for considerably less than 100 hours in the year. That being the case, it was impossible to sacrifice very considerable economies in order to obtain capacity. Under such conditions it was found advisable to force the boilers so as to increase the output from 80 to 100 per cent. above the boiler rating; obtaining rates of combustion of 30, 35 and 40 pounds per square foot of grate per hour by putting a forced draft of as much as 1½ or two inches of air pressure under the boilers. Under these particular conditions, using anthracite grates, there was no inordinate or unusual depreciation in the boiler or furnace or in the tubes. The commercial efficiency of the furnace was such as to make it worth while to do a considerable amount of forcing during that period.

Alex. Dow, of Detroit, accentuated the fact that a furnace cannot be designed or a stoker selected that will give equal efficiency with coals as radically different in their chemical properties as the small size anthracite and the bituminous coals. There are, also, many different kinds of bituminous coal. A furnace designed to give the very highest efficiency must, as the very first condition, have prescribed for it the kind of fuel it is to burn. Free-burning coals such as are used in the economy tests given by Mr. Bement behave entirely different in a furnace than the West Virginia coking coals. They require different proportions of combustion chambers and different handling on the grates. Coking coals must be worked on the grates; while free-burning coals do not require much working. Coals with high fixed carbon can be burned in a comparatively small combustion chamber; but long-flame coals require high combustion chambers. One of the advantages he recognized in the tile furnace construction described by Mr. Bement was that it provided a hot, long and large combustion chamber for the free-burning coal used in Chicago. The chain grate, he said, was probably the best stoker obtainable for Illinios fuel, but it did not follow that it was the best stoker for coking coal. His experience in Detroit, which is on the border line between the coking coal supply and the free-burning Western coal, emphasizes this fact. The Roney stoker had the mechanical advantage that it would handle any class of coal, but could not be designed to be equally efficient with the Eastern bituminous coal with a large proportion of fixed carbon, and Western coal with a high proportion of fixed gases.

In response to a criticism Mr. Bement said that the application of the tiles to the furnace in question in the paper was advised by Mr. Abbott in the particular case referred to, but he had been told of the same scheme being used fifteen years ago.

Mr. John S. Peck, of Pittsburg, then presented a paper on

"Standard Transformer Voltages"

The employment of standard voltages meant, he said, that the user shared in the advantages gained by the manufacturer, and that the possession of transformers which could be used interchangeably on different parts of circuits was an advantage easily appreciated. It meant the necessity of carrying in stock fewer spare parts and the possibility of obtaining such parts much more quickly than when special ones are required. It meant, moreover, the ability to shift apparatus from one part of the system to another, and a great increase in the flexibility of the vital parts of the equipment. His company had adopted for standards the voltages recommended by the American Institute of Electrical Engineers, with such additions as had been frequently demanded in commercial work. For varying these voltages over the desired range, the plan of bringing out taps from the winding was adopted. This permitted a value 5 per cent below normal and one 5 per cent and one 10 per cent above normal to be obtained, which was found ample for almost every condition of service. Where the three-two-phase connection is required, the transformer is provided with taps for increasing the normal voltage by 10 per cent. In standardizing the low-tension voltages, the same plan was adopted as for the high tension; that is, certain normal values were selected and taps brought out for a suitable variation. In many cases, however, the low-tension winding is arranged for series-multiple connection so that two secondary voltages may be obtained. For this condition the same arrangement is adopted as in high-tension work. With transformers for use in connection with rotary converters, an alternating-current voltage is selected which will give the required direct-current voltage. This is considered the normal, and taps are brought out to give values approximately 5 per cent higher and 5 and 10 per cent lower than normal.

In the discussion of this paper, Mr. Moody, of Schenectady, said that in view of the fact that his company had in the past ten years manufactured some 18,000 different transformers, it was strange that any attempt to introduce a demand for new ratios should be welcomed. Many extensive plants, he said, were using transformers for ratios which should not be duplicated, yet it was hardly to be expected that the owners of these plants would throw away their apparatus to accommodate a manufacturer. Frequently, a consolidation of plants brings into one system transmissions using altogether different ratios, calling for new and undesirable ratios to interconnect these systems. Nevertheless, notwithstanding these discouraging aspects of the situation, there was much reason to expect improvements. New plants, which are not tied to past practice, and the reconstruction of older plants would, he said, result in changes in this direction, provided the manufacturer constantly kept before the purchaser the desirability of so doing. He maintained that there was comparatively little to be gained by one manufacturer adopting standards differing from those used by all others; and since there was little likelihood of different companies coming to an agreement as to desirable ratios by direct consultation, some useful agency, like the American Institute of Electrical Engineers, should bring about the desired result. Mr. Moody called attention to the fact that in large units a variation of 10 per cent is usually sufficient, although meaning appreciably greater cost; but with the 15 per cent variation, as suggested by Mr. Peck, there would evidently be 10 per cent more turns and 5 per cent more cross-section in the transformer winding than if there were no such adjustment. Special windings could be furnished for transformers much more readily than any other apparatus, so that the possible saving in the reduced number of designs was not great. The experience of his company was that 5 per cent steps were in most cases too rough an adjustment, and a 10 per cent range with 2½ per cent steps was quite satisfactory except where the ratio must be adjusted at different loads, as when supplying lighting rotaries, in which case much smaller steps and a larger range were usually necessary. With smaller transformers for lighting, there seemed to be less reason for adjustable ratios, since such transformers to give satisfactory regulation at the lamp must be operated from centers of distribution with a negligible or equal drop between the center and each transformer. It would appear that the feeder regulator, rather than the transformer, was the place to adjust for the variable drop in different feeders. His company had for some time made a considerable portion of its smaller transformers with a 1:9 or a 1:18 ratio. This was not an attempt to allow for drop, but to give 110 volts or more for motors in plants having generators that would not admit of obtaining this voltage under full-load. With 2200 to 2400-volt generators, a 1:10 or 1:20 ratio in each transformer will usually answer every purpose. Mr. Moody believed that a permanent adjustment of ratio by taps except in the large units, operating on a line that always carries a considerable portion of its load, was to be avoided, in that the adjustment can be right except for one condition of load, and was, therefore, not a real remedy for variable drop. If a tap is used to obtain a higher secondary voltage than normal, instead of to allow for drop, it is still objectionable, because when in use the core loss is approximately 20 per cent higher and the copper loss 10 per cent less than that for which the transformer was designed. Now-a-days, when so much effort is made to obtain a transformer of the highest possible all-day efficiency, it does not seem desirable to distort a good design so as to increase the all-day losses 20 per cent. Interchangeable voltages, obtained by means of series-multiple coupling of either primary or secondary sections, was unquestionably desirable for the manufacturer and often for the purchaser as well. The extent to which such combinations may be carried, however, reaches its limit when the extra cost of so doing exceeds the saving following the reduction in the number of designs.

Mr. P. D. Wagoner pointed out that in compensating for line losses on the smaller transformers used for ordinary commercial lighting, the use of the tap on the primary to give a higher secondary voltage was objectionable, since during the greater part of the day a voltage would be obtained above that which is desirable for any lamp that might be turned on, and during this period the core losses would be from 18 to 20 per cent higher. Mr. Lieb stated that Mr. Wagoner's remarks did not affect the desirability of having three or more taps on such transformers as are used to reduce the primary voltage for rotary-current transformers. In these cases, it is extremely desirable, where the feeders are of such very variable length to cover large distributing territory, to have at least four or more taps. Mr. C. F. Hewitt endorsed Mr. Lieb's remarks, stating that he had found a second tap of very great value in long lines on which he fed motors in a combined lighting and motor load in the maintenance of a fairly constant voltage on the lighting end of the system. On the end of a long feeder carrying a constant motor load, he found the tap valuable in eliminating the necessity of adding more copper to the line for carrying the load over a long period of time. In certain cases it did not pay to add additional copper to obtain the same voltage at the end of a long motor line as at intermediate points, and in these cases the additional tap was convenient when the load was constant, since it did not make any difference when the motor was not in use whether the voltage was higher or not. Mr. W. G. Carlton, of Chicago, stated that the Chicago Edison Company had feeders varying in length from one to five miles, and that he did not see how they could operate without the different taps on the transformers, when operating on a common bus. Mr. H. J. Gille, of St. Paul, thought the tap on the rotaries for the distribution system was desirable, and also called attention to the fact that it might be a good idea for the manufacturers to connect all transformers before they were shipped. These as received are not marked or tagged, and the taps are in such condition that they have to be tested out. Mr. H. C. Wirt said that considered from the viewpoint of a central station manager, and not that of a manufacturer, the question separated itself into a discussion respecting large and small transformers. He considered that to adopt a primary ratio of 20:1 or 18:1, while it might be convenient for manufacturers, it would not strike central station men favorably. An interchangeable ratio may be obtained by having an additional winding on the secondary, which would cause the core losses to remain unchanged and also to a great extent, the copper losses. But while this method was advantageous to central station men, it would not be so to the manufacturer, since it entailed idle windings which would add too much to the cost of transformer. In his closing remarks, Mr. Peck said that the double ratio of 18 and 20:1 was an advantage to the manufacturer, as it spared him from carrying two kinds of transformers. Taps on transformers were excellent things, and never went amiss, as there are constant instances where they can be used to advantage, and where a new winding would be required were they not present. Mr. Moody said that in the use of two ratios in a single plant it was impossible to obtain the right voltage at any one place under all conditions of load, which resulted in a temptation to make connections to a transformer tap rather than to correct the feeder to keep the drop at the proper amount. As to three secondary voltages, the additional cost of having three rather than two is not great on a transformer of any considerable size, and it is in these cases that it is really desirable to use the third ratio since few small motors are wound for higher than 220 volts.

The next paper taken up was one by J. Henry Hallberg, of New York, entitled

"The Application of Four-Ampere Arc Lamps for Street Lighting,"

an abstract of which will be found elsewhere in this issue. In the discussion which followed, W. D'A. Ryan, of Schenectady, said there was no question but that the 4-ampere lamp had advantages in distribution of light as compared to the 6-ampere lamp. The better distribution from the small unit more than compensates for the higher efficiency of the large unit, if one is not limited by the enforced distance between lamps made necessary by the distance between cross streets. He thought further advantage would be gained by the use of ⅜ inch carbon in place of ½ inch carbon. With a ½ inch carbon, when the light is on one side, the light is three times as strong on that side as on the opposite side. By use of the smaller carbon this is reduced to a considerable extent.

H. C. Wirt, of Schenectady, criticised the use of so small a lamp as one using four amperes. It seemed to him that if the revenue from so many kilowatts capacity output from the station is no greater with the 4-ampere arc than with a larger one, it would be of advantage to the central station to have fewer lamps to take care of. With a smaller light unit the cost of maintaining it is greater, and the cost of wiring is an important fator.

Mr. Lieb criticised the bare statement in Mr. Hallberg's paper that the arc efficiency of the system was 70 per cent in the case of the direct-current constant-potential open arcs on Fifth Avenue, New York, while the 4-ampere enclosed arcs at Cincinnati gave an efficiency of 90 per cent. If all the elements of cost entering into the supply of current were taken into account, he said, the figures from a commercial standpoint would probably be inverted, and he called attention to the fact that the mere statement of arc efficiency did not tell the whole story.

Mr. Hallberg considered that lamps with a closed-base inner globe on a high-tension circuit introduced an element of danger, because as the arc became long and flaming, it might jump across to the lower carbon holder, and possibly ruin the lower part of the lamp. This was the reason for the selection of the open-base inner-globe at Cincinnati. He believed that the smaller globe, that is, the open-base inner globe with a small opening at the top was less liable to damage and breakage than the large closed-base globes, which have a much larger top surface. Furthermore, the closed-base inner-globe is more expensive.

Mr. Ryan, in response to a question by Mr. Bean on the relative spacing of large arc lamps as compared with small, stated that, assuming a certain standard minimum illumination, a 7.5-ampere alternating-current lamp installed every 490 feet would give the same illumination as a 4.4-ampere lamp installed every 355 feet. In other words, in one mile of street it would take 10.68 of the 7.5-ampere lamps, requiring 5180 watts per mile. To get the same illumination midway between the lamps and use the same energy, 5180 watts to the mile would require 4.4-ampere lamps 290 feet apart, or 18.17 lamps per mile. Mr. H. C. Wirt thought 6.6 the smallest arc lamp that should be used, figuring in all the commercial elements of the question.

Mr. Hallberg, in closing the discussion, said that he did not recommend the 4-ampere lamp for the city of Cincinnati. The contract was practically closed when he entered into the matter. If he had known in advance what an engineering proposition it would develop, he might have hesitated. As to the commercial part, would it be possible for the company at Cincinnati to get $146 for one 7.5-ampere lamp? Now it gets $146 for two 4-ampere lamps. When it put in two 4-ampere lamps, the lamps pleased probably double the number of people. One or two individuals might say they were getting a weaker light than they used to have, but ten others were being satisfied by getting the additional lamp. Many of the citizens in any city object to a high candle power lamp directly in front of their houses. In Cincinnati they had a number of complaints from people who objected to having any arc lamps in front of their houses. He thought it was for each individual company to decide for itself, with the citizens of the city, whether they would have the 4-ampere lamp or not. It is working all right in Cincinnati, and conditions are improving.

Mr. Hallberg's paper was followed by another, not exactly on the same subject but kindred to it, entitled

"Notes on Enclosed Arc Lamps"

which was written by Prof. Elihu Thomson, and read in his absence by Mr. Ryan. The author said that the enclosed carbon arc is so different from the arc burned in free air that a few explanations of these differences may be useful. In the open arc the rapid combustion of the carbons by the oxygen of the air adds itself to the effect of the arc proper. The result is that the carbon is burned with tapered ends. In the enclosed arc the combustion is reduced to a minimum, causing the ends of the carbon to remain nearly square or very blunt, with the added necessity for the production of a longer arc and the use of a higher impressed voltage. Any attempt to shorten the arc results, with a well-enclosed arc, in solid carbon deposits on the negative carbon, which may accumulate to such an amount as to shunt the arc like a solid conductor. In the open arc these deposits are formed, but are undercut by combustion of the point of the negative on which they rest, and as a consequence they drop off from time to time, thus relieving the situation. On account of the square ends of the carbon in the enclosed arc, it would be disadvantageous to shorten it, even if the solid carbon deposits did not form. Such shortening would obstruct free radiation of light from the hot ends of the carbon.

The valuable commercial result obtained by enclosing the arc is, of course, a saving of the cost of frequent trimming and carbon renewals. Another result is that single lamps taking a large percentage of voltage across the ordinary low voltage mains can be employed in parallel with incandescent lamps. It may be asked, he continued, whether more complete enclosure of carbons, and the exclusion of air would not give greater life to a single pair of carbons? Experience has shown, however, that it is easy to go too far in checking combustion and that the ideal condition is one in which the carbons undergo a slow actual combustion in an atmosphere which contains at any time only a small amount of oxygen available for union with the hot carbon. The atmosphere is composed chiefly of nitrogen, carbonic oxide, carbon dioxide and what little free oxygen passes in with the leakage air. It is even possible that what oxygen enters the enclosure is combined at once with carbonic oxide to form carbon dioxide, and that the real waste of the carbon takes place from the latter gas dividing its oxygen with the carbon and again forming carbonic oxide in the globe. This is an action which occurs in any anthracite coal fire. With the enclosed arcs burning on constant potential direct-current circuits, there is always such a variation of current that a continual slight pumping action of the upper carbon takes place, the effect of which is to cause the entrance of air to the globe. This automatic ventilation to the inner globe can be so great that in spite of careful fitting of the upper carbon to the opening and care with the other joints in the globe, too much air can enter and shorten the carbon life unduly. Unsteadiness, therefore, due to unstability of current, he said, is not alone detrimental to the character of the light, but may tend to rapid oxidation and consumption of the carbon.

In order to lessen the exchange of air for gases by this pumping action, the cap on the globe was modified. The cap was thickened and an open space or chamber provided near the body of the carbon around the cap. It was as if the cap had been made in two parts, an upper and under floor, each with a fairly closely fitted opening through which the carbon passed and between them an intermediate space having within neither air nor gas alone, but a mixture of both. This decreased the effect of the pumping action. The next move was even more radical. This was the providing of an open but lengthened passage between the outer air and the interior of the globe, independent of the fit of the carbon in the central opening of the cap. In this case the pumping action simply moved a column of air back and forth in the length of the passage. This passage was naturally made in the gas cap itself. The result has been a considerable gain in the life of the carbons. It has even been found that this provision to check leakage was in some cases too complete on closely regulated constant current circuits. The result of this would be soot deposits on the negative on the upper part of the interior of the inner globe, on the cap, and around the upper carbon, where it passed through the cap. The consequence would be a complete failure of the lamp as a source of light. The remedy in such a case is to provide for sufficient leakage which will provide for the proper combustion of the carbon. Since the space in the enclosing globe is restricted it is important that the carbons should burn so that little residue will remain to be deposited on the globe and obscure the light.

The introduction of enclosed arcs has induced the manufacture of exceedingly pure carbons, together with accuracy of form and dimension. Along with this came the possibility of using the type of mechanism now so common in which the carbon itself is fed by the clutch directly instead of being held by a carbon holding rod. Mechanical perfection of the carbons allowed this. The comparatively infrequent feeding action of the enclosed arc also makes it more feasible. The arc flame itself is not a pure white but is strongly tinged with purple. Since the arc flame is longer in the enclosed than in the open arc, the open arc has more of a purple tinge. To correct this these enclosed globes are now made of glass tinged with yellow which has a strong absorption for the blue or violet rays. The glass employed is also generally a thin opal, which causes some loss of light by absorption, but is of great benefit in improving the distribution and increasing the apparent steadiness of the arc. When the arc moves about between the carbons, the amount of light emitted in the various directions changes. This is true to a disagreeable extent when enclosing globes of clear glass alone are used. The conditions which the inner globe must stand without cracking or discoloration are certainly severe. An ideal material for these globes would be fused quartz, if it could be worked cheaply enough.

The economy of light production in the enclosed arc lamp cannot be expected to approach that of the open arc for several reasons. The crater surface is smaller with the enclosed arc for the same consumption of energy, because the volume of current is less and the voltage is higher. The arc flame itself is a poor source of light compared to the hot crater surface. Moreover, the enclosing globe absorbs a percentage of the light, which increases during the run by the partial obscuring of its walls by deposits. Considerable attention Prof. Thomson said, is now given to the introduction of refractory substances into arc carbons for the purpose of providing solid incandescent matter in the arc flame itself, thus giving rise to a condition similar to that of an ordinary candle or gas flame, in which the particles of soot heated by the combustion constitute the substantial light radiating surface. It is not probable that any material will be found, which like the carbon particles in an ordinary luminous flame will burn into invisible gas on leaving the arc after performing its function of being made intensely incandescent after being immersed in the arc flame. Until such material is found, the application of the principle with the improvement of enclosed arc lights, is, of course, out of the question. Other material not answering these specifications would only deposit material on the inner globe.

From this brief discussion, it would appear that efforts should be directed to increasing the purity of the carbons used with enclosed arcs. The lower efficiency compared to the open arc is shown to be unavoidable, but must be taken as compensated for by the long burning without any trimming thus reducing the cost of carbons, as well as the labor and inconvenience.

After the reading of Prof. Thomson's paper, President Ferguson appointed an auditing committee, consisting of Mr. Brady, of New York, and Mr. Lathrop, of St Paul, to examine the accounts of the treasurer, Mr. Anthony, of Chicago, after which the meeting adjourned until Wednesday morning.

THIRD SESSION.

At the Wednesday morning session the following committee on nominations was announced: Mr. Samuel Insull, Chicago; Jas. I. Ayer, Boston, and Mr. Charles R. Huntley, Buffalo. Mr. Charles F. Scott, president of the American Institute of Electrical Engineers, then read a paper entitled:

'The Young Engineer in the Electric Light Plant."

The author said that whereas at one time a college education was a detriment to a man applying for work to a manufacturing company, the output of the electrical courses of our schools is not now equal to the demand. The modern central station system has all of its elements developed by experts, and a knowledge of central station design, construction and operation must be possessed by the man who is placed in charge. The central station engineer must not only have a technical training, but a practical training as well. He needs not only to know what a station is doing, he said, but what it can do. Questions of efficiency and economy are assuming new importance, and in connection with station management there are demands for ability in other lines which a man with engineering instinct and ability is often well qualified to meet. The rate of development of the electrical industries is rapid. More men will be required and it should be the endeavor of the association to do all that it can to promote the development of the best apparatus, the best methods and the best men.

W. B. Jackson, of Madison, Wis., endorsed remarks made in Mr. Scott's paper about the importance of the young engineer going through the dirt and grease and overall stage. He thought the young engineer need have no fear of donning the overalls, but he must not always remain in them. With his superior training, he would if worth anything, rise above them in time, and would be more of a man for having worn them.

Mr. Gilchrist, of Chicago, urged the young engineer not to ignore the business end of the engineering profession. He pointed out the fact that business qualifications are fully as necessary to the station manager as technical knowledge. He must have a broad knowledge of the business.

Mr. Ayer said that the graduates of the technical schools had not proved all that was expected during the ten years that electrical engineering graduates had been turned out in any considerable numbers. In analyzing the reasons for the shortcomings of these technical graduates, he thought that there was too much of a tendency for them to stick to office work, and to go directly into an office from college rather than begin at the mechanical or practical end of the business. He said that young graduates should not be afraid of the practical end of the business, since it would give them a better and broader foundation.

Mr. Lieb advocated technical courses giving a large proportion of mechanical engineering, so that they might be broad engineers and not mere electricians. He further emphasized the importance of training the young engineer so that he would be able to express himself clearly and logically, so that he could present the results of his investigations and his convictions upon any particular point in a clear, logical manner. In other words, he should be able to make a good report.

Prof. Clifford, of the Massachusetts Institute of Technology, spoke very cordially, inviting suggestions from members of the Convention as to ways of improving the training of engineers in technical institutions. He said that suggestions from practical central-station men were the very things needed by those in charge of technical institutions of learning. These institutions should know the defects in "their products," so that they might be able to "remedy them in the manufacture."

Austin Burt, of Waterloo, Ia., said that while the technical graduate might start out on an equality with a common mechanic, he had the training in him which would allow him to grow, as he had found from personal experience and observation.

Prof. Robb emphasized the point that a man should be an engineer first, and a specialist in some branch of engineering afterwards. Physicians and surgeons were not educated as eye-doctors, ear-doctors, etc., but were educated broadly as physicians, and became specialists after years of experience.

Mr. Anthony, of Chicago, made a telling shot when he said that one reason central station managers did not get better results from technical graduates was that these managers were too much afraid to give these graduates information regarding the business. How could the young employe be expected to learn the commercial value of the dollar without any facts to learn it from. One trouble with central station managers was that they carefully bottled up all their information and put it away on shelves, labeling it "poison" instead of giving it to their employees where, it would do some good, so that the employes could have opportunity for increasing the commercial efficiency of the business.

Prof. Goldsborough seconded Mr. Lieb's remarks as to the importance of putting a great deal of mechanical engineering into the electrical engineering course, and making the man a broad engineer. He said, however, that there was not going to be time enough in four years to teach a man the things which will be demanded of him in the future. The course of the future ought to take six years.

Mr. E. F. McCabe thought that a course in modern accounting would be of great benefit to a man who expected to occupy a responsible position in any commercial enterprise. He thought this would be of more value than some of the higher mathematics. The knowledge of accounting is absolutely essential for those occupying the higher positions in a central station enterprise.

A paper on

"Tactful Relations with Customers,"

was then read by Mr. John W. Ferguson, of Chicago. The author pointed out that the success of a lighting company depended upon the popularity of every one connected with the company. Finesse and diplomacy are qualities every solicitor should cultivate, but never at the expense of good faith. A customer ignored is a customer antagonized. Whatever he needs, the company should give him; what he thinks he needs should be found for him; what he has no way of knowing he needs should be shown to him. The discussion following this paper was extended and interesting. Mr. Leon H. Scharsch, of New Orleans, La., told of a very peculiar condition of embittered relations with a customer through an inadvertent remark of a telephone boy in the employ of his company. Mr. J. F. Gilchrist, of Chicago, thought that too often while the men at the head of companies realized the importance of tactful relations with customers, they knew but little of the detail of handling them. Mr. Arthur Williams, of New York, expressed his gratification at seeing electric men all over the country giving more attention to the question of commercial engineering, a term which has been adopted by the General Electric Company and one or two of the other large manufacturing companies. Mr. C. S. Rogers, of Youngstown, Ohio, emphasized the necessity of promptly investigating all claims stating that too often superintendents, who are not responsible for the collection of accounts, do not give prompt attention to the investigation and adjustment of complaints. Mr. C. L. Wakefield, of Dallas, Texas, thought much trouble could be avoided by making contracts as simple as possible. Mr. E. F. Phillips, of Detroit, said that his company found it expedient to tell the customer the truth at all times, regardless of whether the customer was lost or retained, acknowledging when a meter was too fast if such was the case. Mr. Arthur Williams then presented a paper on

"The Attitude of the Employer Toward Benevolent, Insurance and Educational Associations Among Employes."

Mr. Williams said that faithful and continual service had a quality of future value which could not be immediately defined, and for which full compensation could not always be given, in the usual acceptation of the term. Larger recognition is now given to this element in the future of a business than at any time in the past as is evidenced by the increased extent to which employers are interesting themselves in the permanent welfare of their employees. Some employers aim to make their manufacturing plants attractive by comfortable surroundings, good sanitary arrangements, as much light and as little noise and vibration as possible, recreation and assembly rooms, libraries and well-appointed dining rooms. Some employers assist in building homes, some pay for life insurance, some encourage part-ownership, some encourage the organization and assist in the management of relief and benefit associations, and some, like the Pennsylvania Railroad, go a step further, and after a stated term of continuous service provide pensions for life. He gave a review in detail of the various methods pursued by a number of large corporations along the lines indicated. The New York Edison Company had given recent consideration to the subject, but the plans thus far outlined were not yet beyond the stages of earliest consideration.

President Ferguson then read by title a paper prepared by Mr. W. D'A. Ryan, entitled: "Light and Illuminating Engineering."

This paper was not on the programme, and owing to the large number of papers and the time it would take to present the paper in full, it was not possible to have it read.

FOURTH SESSION.

The first paper at the Wednesday afternoon session was presented by Dr. J. D. McCowan, the title being:

"First Aid Appliances."

This paper, which was of a nature impossible to abstract, gave sensible instructions for the assistance which might be rendered to an injured person before the arrival of a physician. The paper was accompanied by demonstrations of many points.

In connection with this paper Dr. McGowan exhibited a case of first-aid appliances which is the Chicago Edison Emergency box, devised by W. L. Abbott, chief operating engineer of the Chicago Edison Company. This case is about half the size of a portable folding meter case, and contains a box of Edison ointment, gauze bandages, a first-aid package, and a syringe for hypodermic injections of strychnine, to be used in case of electric shock.

It was moved by Mr. Gille, of St. Paul that Dr. McGowan's paper be printed in sufficient numbers so that member companies could put it in the hands of all employes, and the motion was carried.

Mr. Lieb asked whether an electric burn was more serious or different in any way from an ordinary burn, and in reply Dr. McGowan said that burns received from short-circuit flashes were like the burns from any other flame, the seriousness of which depend upon the amount of heat to which the exposed part was subjected. In the case of burns made by contact of some part of the body with a high-tension circuit, the tissues were probably made dead, and destroyed. In such cases the burns frequently took months to heal, as time must be allowed for new tissue to form to take the place of that destroyed. In response to a question as to what to do in case of a flash received in the eyes, he recommended first putting in sweet oil and then using a saturated solution of boracic acid every hour or two. If the pain was very severe, a 2 per cent solution of cocaine might be put in the eye once.

W. B. Jackson asked what should be done in case of spasms resulting from electric shock. Dr. McGowan said that a hot bath was the best thing for these. Mr. Lewis spoke of a case where powdered bismuth used on a burn resulting from an electric shock had resulted in very quick healing. Dr. McGowan urged strongly that a man should not be given up as dead after electric shock until attempts at resuscitation by artificial respiration had been kept up for seven or eight hours.

The next paper taken up was by Prof William Lispenard Robb, of the Rensselaer Polytechnic Institute, of Troy, N. Y., on

"Steam Turbines."

In opening the discussion of this paper, the president called upon Mr. W. L. Emmet, of Schenectady, who gave a sketch of the principles of the turbine as developed by Mr. Curtis and pointed out that in the Curtis turbine the water due to expansion is taken out in successive stages in more or less proportion, and does not take part in the subsequent expansions; consequently all the superheat that can be used is available and acts sufficiently without having to expend its energy in re-evaporating water. Experiments with the Curtis turbine have shown that the elimination of initial moisture or moisture at any stage by the addition of superheat is beneficial to the turbine, and the improvement in increased superheat is indefinite, being represented almost by a straight line. Hopes as to the future economy of turbines of this type are based to a great extent on the proper elimination of the moisture and the proper use of superheat.

He said that large tubines and small turbines were nearly equally efficient, but it is hoped that with the large machines there will eventually be great improvements in efficiency, for the reason that a certain amount of clearance is necessary for mechanical reasons, and that clearance can be made less proportionately as the turbine increases in size, while the leakage and dissipation from improper fittings will be relatively less, as well as friction and radiation losses. A turbine of 600-kw. capacity showed an economy of 19 pounds of dry steam per kw.-hour at full load, and only 1½ pounds greater at half load. Mr. Emmet said that in turbines the increase in economy has been about 1 per cent for every 12° of superheat. In a turbine of the Curtis type, the capacity is practically unlimited without any increased expenses, because by simply adding more nozzles, more power can be gotten out of the turbine. The economy would fall off somewhat with great overloads. Back pressure is rather more objectionable in the turbine than in the steam engine, and the turbine is relatively less advantageous non-condensing than condensing. One of the great advantages of the turbine is in its ability to use high degrees of expansion, and when working non-condensing this advantage is lost. Up to the present time little or nothing has been done toward competing with the non-condensing engine the details of commercial turbines being worked out on the condensing basis. In reply to a query Mr. Emmet said he thought the gas engine had a future, but it is expensive to build and maintain and the same is true of its accessories. Turbines do nearly as well as the gas engines, and he thought the latter would receive a great setback because of the development of the steam turbine.

Mr. Edward Yawger, of Pittsburg, Pa., said that the floor area at present actually used by turbines is about twice greater than is necessary. It has been suggested that the surface condenser should be made a part of the foundation of the turbine, but the objection to this is that it would necessitate the turbine manufacturer being also a manufacturer of the condenser, and it might possibly restrict accessibility to the condenser. Owing to the turbine occupying such a small space it can be set up on temporary foundations and thoroughly tested under load before shipment. In the Westinghouse shops the testing room contains foundations of a sufficient size to take 5,000-kw. turbines, and there are also surface condensers of large capacity, pumps, an independent superheater, etc. It has been the practice so far of this company to thoroughly test every turbine, not only at full loads, but at smaller loads, down to ⅕. Up to the present some 500 such tests have been made on turbines.

Replying to a question, Mr. Emmet said that owing to the great expansive limit of the turbine, it is much more efficient at high vacuums than the steam engine. He said that in the smaller turbines the clearance is .03 inch and .05 inch in the largest turbines, which clearances are found to be ample. One of the objects in building the turbine in vertical position is to make it short, to simplify the bearings and render expansion of the metal unimportant. The pressure on the step bearing is governed by the size, it being 800 pounds per square inch in the smallest turbine and about 1000 pounds in the largest machines. In reply to a question as to heating of the generator, he said that since the steam is expanded down to atmospheric pressure before entering the pressure shell, the temperature is only about 212°; and since there is vigorous ventilation in the rapid moving machine of this kind, no trouble has been experienced from the effects of heat.

The discussion on the turbine was postponed until the next session of the convention, and the convention adjourned at 4 P. M. until Thursday morning, in order to give the delegates an opportunity to visit the new station of the Chicago Edison company, and to inspect the turbine about to be installed in that station.

FIFTH SESSION.

The Thursday morning session was opened with the reading of the report on

"District Steam Heating"

by Mr. John W. Glidden, of De Kalb, Ill. His committee found that there were about 100 district heating plants in operation in the United States. About ten of these were live steam heating plants operating solely for the heating business. The remainder were about two-thirds exhaust steam plants and one-third hot water heating. A list of questions was mailed to all of these plants, but owing to lack of information on the part of central stations, the replies to these were on the whole very unsatisfactory and of little value. The writer visited about twenty heating plants, and personally interviewed the managers. Aside from the plants located in the cheap coal belts where screenings can be delivered for about $1.00 per ton, and a few other plants where the gross receipts are at least 60 per cent of the investment in mains, there was very little enthusiasm among heating managers. The representations which induced many of these men to go into the business had not proven out, and they were left with large plants which they are continuing to operate because they do not know what else to do with them.

Personally, Mr. Glidden thought that even though it were demonstrated that the present conditions of the business would not warrant central station men going into it purely for the direct financial returns, yet the public had become so thoroughly convinced of the desirability of district heating that if a central station did not occupy the territory it will be occupied by merchants' associations. These associations would at the same time engage in the lighting business and jeopardize the investment of the older companies. If we grant that the demand for district heating is to be met by someone, said Mr. Glidden, is is not fair to expect that central stations can best meet it? They have some available apparatus already installed, they have the technical knowledge and the organization, and may have to go in for their own self-protection. The appointment of a committee to work continuously on the heating business, to encourage managers to keep more definite data and make tests to show what becomes of the actual number of heat units sent out, would remove it from the field of haphazard experiments and make it an exact science.

Mr. C. R. Maunsell, of Topeka, Kansas, said there was no doubt whatever that a demand for steam business exists. In his town the demand greatly exceeds the capacity of the company. After considerable discussion a motion was carried to appoint and provide for financially a permament committee to secure data on this subject. Further discussion on the steam turbine was then taken up by Mr. J. W. Glidden, Mr. Maunsell, Mr. J. C. Gillette, Mr. Harold Alwert, Mr. Edwin Yawger, Mr. George S. Carson, Prof. H. E. Clifford, Mr. H. J. Gille and Mr. M. W. Hanks. A paper by Alexander Dow, of Detroit, Mich., on "Salt as a By-Product," followed. As this paper was rather novel in its nature, there was no discussion, and the next paper by Prof. H. E. Clifford, of the Massachusetts Institute of Technology, on

"Some Fundementals in Photometry,"

was taken up. The author uged the necessity of thorough calibration of instruments with due regard to the time element. He spoke disparagingly of the Lummer-Brodhun photometer for use by the average man; he spoke well of the Kruss-Bunsen photometer, and said that the Jaly photometer gave results far too low. He recommended the Koenig spectro-photometer as a means for ascertaining exactly whether a photometer was giving a true reading. Referring to the use of the Nernst lamp as a satisfactory standard, the author found that the lamp did not give its normal candle-power until a considerable time after current was switched on. He also found that the Nernst lamp was particularly sensitive to any change in voltage, a change of 5 volts on a 225-volt circuit for only half a minute producing an effect such that the lamp does not recover its normal power for a period of ten to twelve minutes after such fluctuation. He referred to the following effect to be guarded against in photometers: If two lamps are compared, one of a decided bluish tint and the other of a decided yellowish tint, it will be found that the blue lamp has the advantage at greater distances from the photometer disc, and the yellow at lesser distances, although they may be actually at mean distances of the same intensity. Speculating that this color effect might be at the bottom of the irregularities mentioned, the author describes an experiment with Nernst lamps screened with blue and yellow discs. The one screened with a blue screen gave a light very much of the same color as that obtained from the enclosed arc lamp; and the other screened with a yellow screen gave a light similar in color to that obtained from an incandescent lamp. The colors were fairly translucent, but not opaque. As a result of these experiments, the author concludes that it is necessary either to use a screen of the same color as the arc in arc-light photometry, or else discard photometric measurements of the arc light as a means of rating. He recommended that arc lights should be rated by the illumination which they afforded.

Before any discussion was had on Prof. Clifford's paper, President Ferguson called for the report of Prof. Matthews, of Purdue University, Lafayette, Ind., on the

"Investigation of Photometric Values of Arc Lamps."

In the discussion, Prof. Matthews said that that committee on arc-light photometry had taken into consideration in their measurements the color effect referred to by Prof. Clifford, and had found that the only way to overcome the error due to that effect was to make the illumination of the disc quite low. His committee had during the year given attention to the Nernst lamp, the Welsbach mantle burner, and the open gas flame. The watts per candle-power found for a single-glower Nernst lamp were 2.3, about the same for a three-glower lamp, and 1.8 watts for a six-glower lamp. An important factor in the Nernst lamp was the excellent quality of light. In the testing gas jets, the lights from a large number of tips were compared. Although the different tips looked alike, the candle-power which they gave ran from 7 to 27 candles. In reply to a query, Prof. Clifford said that in the Nernst lamp when the voltage is dropped by 10 volts, held for one minute and then restored to its normal value of 226 volts, the ratio of change in illumination was about 5.4:4.8 and the lamp did not return to its full voltage until after a period of about ten minutes. In the case of a drop in voltage of 5 volts, the ratio became 5.1:2.7 and the lamp did not return to normal power for a period of four and a half minutes. Mr. M. W. Hanks said that if the pressure be dropped, the candle-power of the Nernst lamp will also drop. On raising the voltage again, the candle-power will not go up instantly to its full value, but for all practical purposes of general illumination this is a matter of little moment. Mr. Hanks said that Dr. Nernst had been using one of his glowers for standard work. This glower is operated in the open air, and the glower is heated by means of an alcohol torch. All the ballast is in series and the candle-power is maintained constant by maintaining the current constant. The light he employed in photometry comes through a slit, which eliminates terminals. Mr. Arthur Williams said that in some tests with the osmium lamp the voltage was increased from the normal voltage of 50 to 80 volts, with a corresponding increase of candle-power. After the voltage was restored to normal, however, the candle-power was only about 50 per cent of normal and it took some time for the lamp to recover. Prof. Matthews said that in some tests the Nernst lamp, starting at 210 volts ran to 230 volts (220 being normal) with practically straight-line relation. A change of one per cent in the voltage made a change of 7 per cent in candle-power; at 220 volts the candle-power was 27, and at 230 volts the candle-power became 59. Much more uniform candle-power was obtained at constant current than at constant voltage. Mr. Ryan said that when the Nernst lamp was first introduced the light was white and the lamp had a high efficiency but a short life. The life has been prolonged, the efficiency has been reduced somewhat, and the light of the lamp to-day is nearly the same in quality as that of the incandescent lamp. Mr. Ryan considered that the open arc lamp with an opal globe gave a better light for the comparison of colors than the enclosed arc with a clear globe. A globe could, however, be selected for the enclosed lamp so that its light approximates to the average light. The disadvantage of the open arc light in comparing colors is the fatigue effect. Prof. Matthews suggested that matching colors should be done with the same light as that in which the colors will be used. Prof. Jackson pointed out that whereas arc lamps and incandescent lamps operated on low-frequency circuits gave an unsatisfactory light, the Nernst lamp on account of the large mass of glowers shows very little variation in illumination at a frequency as low as 25 periods per second, and he thought that the Nernst lamp might be worked at a frequency as low as 17.5 periods. Prof. Matthews then exhibited the integrating photometer invented by him, explaining its operation.

Mr. Arthur Williams, of New York, presented his report on "Decorative and Sign Lighting." Mr. Williams' paper was gotten up in a most artistic pamphlet form worthy of careful preservation. It contained illustrations of many classes of decorative lighting, the engravings including views from the Pan-American and other recent expositions and samples of especially fine sign and decorative lighting found in some of the larger cities.

SIXTH SESSION.

On the opening of the Thursday afternoon session, Mr. William Cooper, of Cincinnati, Ohio, read his paper on

"The Relative Advantages of Electrical and Mechanical Methods of Variable Speed Control for General Power Service,"

a full abstract of which will be found elsewhere in this issue. This paper was discussed at length by Mr. A. W. Lloyd, of Chicago, Mr. H. M. Lyman, who presented a communication on the subject, Mr. H. J. Gille, Mr. Arthur Williams, Mr. J. W. Lieb, Jr., Mr. F. W. Bowen, Prof. Morgan Brooks, Mr. C. W. Coiner, Mr. H. T. Hartman, Mr. Frederick J. Pearson, Mr. F. E. Smith, Mr. Harold Alwert, and Mr. Cooper.

Mr. A. W. Lloyd said that in Chicago the cost of driving machinery by gas engines is about the same as with electric motors, but the latter have greater advantages otherwise. The Chicago company takes out a great number of gas engines every year and replaces them with electric motors. He considered that from the central station standard, at the present time a motor will answer all purposes operating on two voltages with a resistance in the field and perhaps also in the armature. He considered that the installation of small motors for groups of machines is more economical than the individual drive. Another objection to applying individual motors to old tools is that the tools are generally too light in construction. In the case of very large and heavy machines, however, the individual motor is preferable. Mr. H. M. Lyman, of Chicago, called attention to the advantages of the three-wire distribution and special motors over the four and five-wire systems and standard motors. The voltages of the three-wire system applied to the armature of a special motor permit a perfectly gradual one-to-four variation of speed. A two-to-one variation is ample for planers, slotters, milling cutters and many other tools. Lathes and boring mills require in extreme cases four-to-one variation of speed on a single job, while on different jobs a range as high as one to 12 or 16 may be required. As the cutting speed of the tool is very nearly constant, regardless of the rotative speed, the power taken by a machine is nearly constant for all motor speeds, and the motor must, therefore, be large enough to deliver full load at the lowest speed. It is better to have one of two changes of speed by gearing, than to furnish a motor capable of a full range of speed. The four or five-wire multiple-voltage system had signally failed in cases because the motors were not sufficiently large to furnish the power required when running at their lowest speed.

Mr. H. G. Gille said that in using a variable-speed motor on the three-wire system, unless the neutrals cared for the capacity of the outside feeders, there is likely to be trouble. Mr. Lloyd stated that in Chicago motors of a capacity as high as 15 horse-power were operated on the regular street system, and that recently a 30 horse-power motor was installed, but close to a sub-station. Mr. Cooper doubted if the five-wire motor system had failed in any individual case for the reason given, and added that the use of the system was largely increasing. Mr. Arthur Williams said that the experience in New York was that at present prices for electric current for power, there is no chance for the gas engine in competition with the electric motor. He cited an instance where a gas engine that was about to be installed would have cost $3,500 a year to operate, whereas electric current for the same service had cost only $2,700 per year. During the last several months the New York Edison Company has taken out an average of from six to eight gas plants a month. Mr. John W. Lieb considered that the experience of central stations was entirely at variance with the statement that the gas engine is a competitor of the electric motor. Mr. F. W. Borne, of Kenosha, believed that the matter of competition between the gas engine and the electric motor was not only a question of the cost of gas and price per kw-hour of electrical energy; that there were cases where customers would be willing to pay ten times more for electric power than for gas engine power. Mr. Williams stated that a gas engine cannot be run on 20 ft. of gas per horse-power hour, and he knew of no test where they consumed less than 30 or 40 ft. of gas per horse-power hour. Mr. C. W. Coiner, of Oneida, N. Y., said that in Oneida his company controlled both the gas and electric plants, and while they were selling gas for power purposes for $1.00 per thousand, and current for motor purposes from 10 cents down to 2 cents per horse-power hour, yet the motor was almost invariably preferred for power as against the gas engine. Mr. H. T. Hartmann, of Philadelphia, related that in Canton, Ohio, where natural gas sells for 25 cents per thousand, which gas, moreover, is more efficient for use in gas engines than manufactured gas, his company has over 900 horse-power of electric motors connected in the town of 30,000 inhabitants. Customers find that the reliability of the electric service is more important to them than the cost. Mr. F. J. Pearson, of Chicago, considered that for driving machine shop tools and devices of that character in manufacturing plants, the two-voltage system has proven to be entirely satisfactory. He said that recently two gas engines were replaced with motors, and it was found that the item of labor in the case of the gas engines was 65 per cent higher and the cost of oil and other materials 50 per cent greater. Mr. F. E. Smith, of Somerville, Mass., gave examples where gas engine power was replaced by electric motors, and where a reduction in total expense of power followed; and in one case where the cost of electric power was considered greater, the customer was satisfied, owing to the better service. Mr. Harold Alwert, of Oak Park, Ill., related that at a recent meeting of mechanical men in Chicago a conservative gas engine representative stated that he had ceased representing that gas engines needed no attention, and that he would not now guarantee engines unless an attendant of superior intelligence to that of the ordinary steam engineer was put in charge of the plant.

The next order of business was the reading of the report by Mr. Robert L. Elliott, of Chicago, on

"The Theft of Current."

The report stated that electric lighting companies were obliged to entrust all kinds of people with their product, and it could not be wondered at that dishonest persons so entrusted would occasionally seek means to avail themselves of it without the knowledge of the company. The committee hesitated to assert that certain classes in a community should be watched, while confidence could be placed in others. It would be unwise to say, for instance, that those who were usually classed among the higher grade of citizens could be trusted not to steal current, as experience has proved otherwise. Companies would do well to make their investigations general, so far as people are concerned. There were, however, people in certain lines of business who, as experience had shown, were deserving of more suspicion on the part of companies than others. In cities theft of current occurred most frequently in saloons. Restaurants, hotels and theatres may be said to come next. As aiders and abettors, tramp wiremen had given the most trouble. They could bear close watching by the electric light companies. Buildings having isolated plants in which the company furnishes part of the electricity should also be given close attention.

The methods adopted of stealing current, the committee said, may be classed under the following general heads:

Tapping wires before they reach the meter; connecting meter taps together after the meter is removed; attaching wires in a temporary manner to service switch or cut-out boxes; tapping the power meter for light where customer pays a lower rate for power than for light; disconnecting one of the outer wires at the service switch and connecting it to the other wire, thereby throwing all the lights on one side of the three-wire system; cutting or pulling out the armature wire of the meter, removing the fuse from the switch or cut-out, thus opening the meter armature circuit; inserting wires into the case of the meter so as to strike the disc and retard or stop it; forcing dust or insects into the works; inserting short wires or iron filings into the meter, which cling to the magnet and drag on the disc; lowering the jewel screws so as to allow the disc to rest on the magnets; breaking the seals or seal wires of the meter, so as to take off the meter case and gain access to the dials; breaking the window protecting the dials or removing the glass by prying the glass guard open and slipping the glass out; unscrewing the meter from its fastenings sufficiently to throw it out of level.

The report stated that constant and careful inspection by employes was, of course, a great necessity. Any marked decrease in the customer's consumption which could not be accounted for by the quantity of electricity he customarily used should give rise at once to the careful inspection of the wires and meters on his premises. Tampering with meters and the meter connections took on many different forms, which were hard to detect unless very closely watched. When a case of theft is discovered, an effective way of ascertaining the amount of which the company is being defrauded is to secretly install a test meter on the line where it will not excite the suspicion of the offender. The tapping or tampering discovered should be witnessed by more than one person. Ordinarily a few sharp, competent employes, acting under the direction of the legal department, would be able to accomplish what was possible in this respect.

Mr. P. H. Bartlett, of Philadelphia, opened the discussion on this paper and said that the only thing his company was doing at present to prevent theft was to encase the service wires and cut-outs and all wires between the service and the house cut-out in an iron box. The old-style service end was discarded and an L-box used, in which one end of the conduit terminates, the other end of the conduit terminating in the service cut-out box. The box and meter are mounted on a light angle frame held away from the wall, and the meter itself is set over the box in such a manner that the wires pass directly into the bottom of the meter and back again through the back of the box, and by a conduit into the house conduit or switch. By this means there is no connection with the wires from the street and the house cut-out or switch that could be tampered with, so that the only thing the company has to look out for is tampering with the meter itself. Trouble was experienced by persons removing the dial glass and turning the dials backward. This was only discovered through an accident, and the consumers who did it evidently understood the meter thoroughly, as they turned back each point just enough so that the relation of one point to another was about correct, and the amount turned back each month was about the same. Mr. John L. Gilchrist said that he had been informed that in England convictions for theft of current had been obtained under the old English law. Mr. Elliott added that in Germany convictions had been secured on the ground that theft of current is larceny.

The last paper to be presented was a report by Mr. L. G. Van Ness on

"Unaccounted-for Current."

Lost and unaccounted-for current in alternating distributing systems may be classified under four heads: Transformer iron loss, resistance loss, meter shunt loss and unaccounted-for current. For direct-current distributing systems the list is the same, with the omission of transformer iron loss.

Transformer iron or core loss is very easily calculated by multiplying the loss per transformer by the number of transformers in circuit, and multiplying this by the number of hours of operation, when the transformers are of the same size. When various sizes are used it may be calculated for the different sizes and footed for the totals. If transformers have not been tested in the testing room, the maker's guaranteed loss may be used, if due allowance is made for aging of the cores. An allowance should also be made for the voltage under which the transformers are operated, if makers' tests are not at the same voltage at which transformers are operated. Within small limits core loss will increase about 2 per cent for each 1 per cent increase in voltage over the test voltage.

A comparison of two districts, one supplied by isolated transformers and the other by individual transformers, will at once give an idea of how much money might be spent to install a three-wire secondary system, as much less transformer capacity will take care of the same load on a three-wire net work than with isolated transformers.

The resistance loss may be calculated by comparing the average voltage of the lamps on a circuit with the voltage carried at the station as determined by the station records. This difference in voltage represents the resistance and reactive drop of the feeders, which, multiplied by the current carried by the feeders at the same time and by the power factor of the circuit, will give the watts lost in the distributing system for that particular load.

There is another and more complicated way of calculating the resistance loss, which may be used to check the previous methods. This is to calculate the loss of the feeders by taking the size and length of the feeders and calculating the resistance loss for one ampere, flowing to the first point of division. From this point to the end of the circuit, if the one ampere considered is divided in proportion to the connected load on different branches, the resistance loss may be calculated accurately to the end of the feeders. From this value per ampere the all-day loss may be calculated by taking the station ammeter readings at intervals during the day, squaring them, and multiplying by the loss per ampere. Secondary losses may be calculated in the same manner. The cost of furnishing this current that is lost in the feeders will give indication of the time when it will be proper to make an expenditure to reinforce the lines.

Meter shunt loss is calculated by determining by test the loss in each type of meter of each size, and multiplying the result by the number of each type and size. Meter shunt loss, while not considered serious, will sometimes show more than transformer iron loss. This is quite possible in a residence district fed by a carefully designed secondary network.

The author thought that if manufacturers would devote as much time to developing an ampere-hour meter as they spend trying to improve the wattmeter, they might invent a meter that would serve central station purposes much better. With good regulation, one can calculate the consumption for an alternating-current incandescent load as accurately with a correct and sensitive ampere-hour meter as it can be measured by a wattmeter. This would eliminate a loss that amounts to from 16 to 36 kilowatt hours per year per consumer.

The unaccounted-for current is that due to faulty registration meters, thefts of current and leakage by grounds and underground systems. There is really no good excuse for losing records. The following are some figures on three representative alternating current circuits:

	1	2	3
Voltage	2,000	1,000	1,000
Connected Load, Kw.	337	461	351
Maximum demand, Kw.	176	81	88
Number of transformers	12	16	145
Cap transformers, Kw.	130	135	160
Number of meters	182	266	308
Trans. iron loss, %	3.6	15.4	42.7
Resistance loss, %	4.5	6.5	6.3
Meter shunt loss, %	.8	5.2	1.4
Unaccounted for, %	13.3	1.7	1.1
Sales, %	77.8	71.2	48.5
Output, %	100	100	100
Output, kw-hours	35,386	9,135	20,000

The first is a well-designed feeder supplying a business district on a three-wire net work. The second is a carefully designed feeder supplying a residence district on a three-wire network. The third is a feeder with isolated transformers such as we often find, that has been added to from time to time, and no attention paid to economy of operation. This feeder supplies a mixed residence and business section, and was changed with very little expenditure to an efficient distributing system. Unaccounted-for current shows an abnormal amount under feeder No. 1. The natural course to pursue would be to check up all meters in that district, and if no large meters were found dead, it would be necessary to make a search for taps taking current without measurement. Feeder No. 3, while it appears to a great disadvantage besides feeders 1 and 2, is by no means unusual. There are many operating under the same conditions every day, and few realize the cost of their operation.

Table II.—Showing legitimate losses on five carefully designed feeders supplying all classes of business.

		Trans. Iron Loss.		Resistance Loss.		Meter Shunt Loss.		Output.
	Voltage.	Watt-hrs.	Per Cent.	Watt-hrs.	Per Cent.	Watt-hrs.	Per Cent.	Watt-hrs.
1	1,000	28,488	6.76	23,923	5.68	14,916	3.54	421,000
2	1,000	19,752	3.78	25,086	1.98	19,092	3.65	522,400
3	1,000	28,680	9.56	17,026	5.60	23,316	7.77	300,000
4	2,000	20,712	5.01	29,691	7.28	24,504	5.93	413,000
5	2,000	42,576	8.55	28,867	5.79	18,720	3.76	477,600

Table No. 2 shows output and losses for an average winter day for five feeders which have received considerable attention in the way of design. In this table, on feeder No. 4, the meter shunt loss amounts to more than the transformer loss. The conditions here were such that the transformer capacity could be so installed that very little more than the demand of the feeder was necessary in order to give proper regulation.

Mr. Hartman, editor of the "Question Box," which was published in pamphlet form and contained 257 questions, was then introduced, after which the meeting adjourned to executive session. While in executive session, an amendment to the constitution and by-laws was adopted, making the dues of associate members $20.00. Through an oversight in an amendment adopted at the Cincinnati convention, the matter of dues of associate members was inadvertently omitted. The report of the committee on nominations was then presented, and the following named gentlemen were elected as officers for the ensuing year: President, Mr. Charles L. Edgar, Boston; first vice-president, Mr. S. B. Livermore, Winona, Minn.; second vice-president, Mr. John W. Lieb, Jr., New York. Members of the executive committee for three years: Mr. Louis A. Ferguson, Chicago; Mr. H. A. Bottomley, Fall River, Mass.; Mr. Alexander Dow, Detroit, Mich. President-elect Edgar in a speech from the chair thanked the association for the honor conferred upon him, saying:

"I recognize that it is an honor to be made president of this Association. It was my good fortune to be vice-president in 1890. It is impossible to describe the difference between the meeting of the Association in 1890, at Cape May, and 1903, in Chicago. I recognize I have a hard row to hoe. Each president naturally desires to make his meeting somewhat better than the previous one; and I know you will all admit I will probably not make the meeting next year anywhere equal in interest and importance to that through which we have just passed. I do not know that I can say a word more to emphasize it than that the success of this meeting is due to Mr. Ferguson. We all feel it, and we hope he appreciates the fact, that we know he as president has done more to promote the interests of the National Electric Light Association than any previous president."

On motion of Mr. Scoville, a vote of thanks was tendered to the retiring president, who expressed his appreciation of the association's sentiment and his thanks for the attention which had been given to the papers and for the assistance which had been afforded him during his administration. President-elect Edgar announced that a paper had been sent to the convention by Prof. Elihu Thomson on

"The Development of the Electric Power Station."

This paper reviewed central station development, beginning with twenty-five years ago, when dynamos were of exceedingly small capacity, when one using 25 or 50 horse-power had a very large output. The evolution of steam practice in central stations from high-speed belted engines to slow-speed direct-connected units was reviewed, bringing the paper down to modern steam turbine practice, reviewing briefly the advantages of the steam turbine.

Looking to the future, the author put aside, as improbable, the conversion of fuel into electrical energy, inasmuch as no promising signs of its possibility were forthcoming; but it seemed that it would be necessary at last to turn to those forms of prime movers which had inherent possibilities of developing much higher efficiencies in the use of fuel than the steam engine. At present in relatively very small units, he said, the internal combustion engine, such as the oil or gas engine, had shown efficiency nearly double that of the best steam engine plants. It seemed probable that an efficiency of heat conversion about three times better than was attained with steam would some day be practicable in large units. The engines would naturally be of the large reciprocating type and comparatively slow speed, unless some form of gas turbine was developed, a matter upon which serious doubts might be expressed. Such a machine would demand the pumping of the air and gas prior to their combustion. Various other matters in connection with gas engine practice were briefly discussed. In the considerations advanced in the paper the use of water power was purposely neglected.

A paper on the "New Form of Arc Light Photometer," by Mr. R. R. Lawrence, was read by title.

The report of the treasurer was presented, and showed the following financial transactions during the year:

Receipts, including balance, 1902	$17,091.52
Disbursements	8,439.55
Balance	$8,651.97

In connection with the report of the Committee on Standard Rules for Electrical Installation, the following resolution was passed:

Resolved, That a vote of thanks be tendered the Committee for its diplomatic and effective efforts to secure a reasonable and practical set of rules;

That the Association expresses its appreciation of the importance of co-operation with the National Board of Fire Underwriters in work where mutual interests are involved, and that it recognizes the value of the results obtained since there has been such co-operation;

That a set of the rules and the report of the committee be printed and sent to each active member of this Association, and that action on said committee report be deferred until the next regular meeting of the Association;

That any change in the personnel of the committee for the coming year be referred to the incoming president for such action as he may deem desirable.

On motion of Mr. Scovil the following resolution was passed:

Resolved, That the proper officers of this Association suggest to the National Underwriters' Association that they would consider it a compliment if they can see their way clear to include the cost of their electrical inspection in their rates.

The action taken at the Cincinnati convention fixing the place for the 1904 convention at St. Louis was reconsidered, and the matter of the time and place for the 190' convention was left with the Executive Committee. Boston was subsequently selected. It was also voted to hold a special meeting in St. Louis in September, 1904, in conjunction with allied organizations.

On motion of Mr. J. G. White, of New York, the thanks of the Association were given to the electrical interests of Chicago, particularly the officials of the Chicago Edison Company, for the information, assistance and attention given and rendered to the delegates to the convention, and the secretary was also instructed to send a copy of the resolution to the chairman of the Entertainment Committee, Mr. J. Wolff. The convention then adjourned.

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BOILER AND FURNACE EFFICIENCIES.

BY A. BEMENT.

It is not the object of this paper to treat of boiler and furnace efficiencies in general, but to discuss some features of the performance of modern standard apparatus. For this purpose two types of boilers, two furnaces and one stoker have been selected; one of the boilers, however, owing to changes made in it, may be considered as a third type. One of the boilers is 12 tubes high and 16 wide, provided with a superheater and rated at 400 horse-power. It is equipped with a chain-grate stoker of 65.5 square feet; the gases from the fire discharge among the tubes of the heating surface located immediately above, thence down across the tubes of the second pass and finally rise on the way to the flue across the tubes of a third pass. This boiler is referred to as boiler *A*. The other boilers are of two sizes. That designated as No. 1 is 15 tubes high and 19 wide. No. 2 is 17 tubes high and 19 wide. With each the gases travel from the bottom of the back and diagonally across the tubes to the upper front end, thence back between the drums to the flue. No. 3 adjoins No. 2 in battery, and is identical with it except that the path of the gases from the back end is forward among the lower tubes of the second to the seventh rows; thence to the front end of the boiler, then back among the next five rows and finally forward among the upper five rows, where they pass between the drums to the flue. In this arrangement the gases traverse the length of the tubes three times in place of the one diagonal travel of boilers Nos. 1 and 2. ~~The furnaces~~ under these boilers are identical, and each is fitted with a chain-grate stoker of 72.2 square feet. The tubes in the lower row of the boiler are entirely encircled with a fire-brick tile from the front to a point back of the bridge-wall; for the remainder of the distance to within four feet of the back end the usual tile furnished by the maker of the boilers is used.

The expression "boiler efficiency" is used to designate the performance of the boiler only, not that of the combined apparatus; it implies the measure of the cooling effect produced on the hot gases, and not radiation and moisture in the steam.

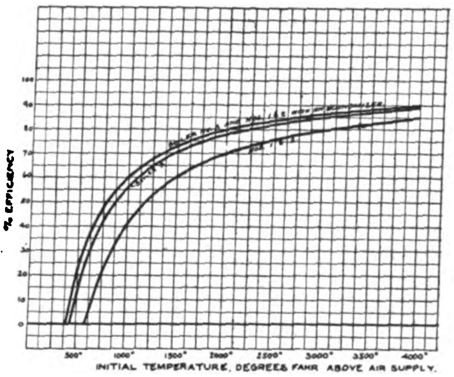

FIG. I.—EFFICIENCY CURVES.

The experimental work herein mentioned had three objects: first, to determine the relative efficiency of boiler *A* and boiler No. 1, and second, the relation between the efficiency of the same boilers and their furnaces based on combustion and heat absorption, neglecting loss of combustible in the refuse. The two relative values to be determined were, for the furnaces, the loss due to escaping hydrocarbons and incomplete combustion, and for the boilers, the cooling effect produced. With Nos. 2 and 3 it was desired to determine the relative cooling effect only.

The efficiency of a boiler will be influenced by the initial or furnace temperature, and by the capacity at which it is worked. So as the horse-power increases the effect is to lower the efficiency, and as the initial temperature is lower, so is the heat transfer, and as a smaller boiler will absorb less heat than a large one, the determination of its efficiency according to some standard becomes a complicated problem. With the measure of performance of the combined boiler and furnace based on water evaporated from and at 212 degrees, a factor of evaporation has been devised to place different conditions on a common basis, but no factor, or set of factors, has as yet been devised to reduce various boiler performances to any standard of comparison. Therefore, to determine the difference in efficiency between the boilers to be compared, requires in each case that the amount of heating surface, initial temperature, and amount of water evaporated, be the same. These requirements were very closely met in the comparative test between boiler *A* and No. 1, and also between Nos. 2 and 3. In fact, the performance of the four boilers is so nearly on the same basis as to be suitable for comparison.

Table I.

	Boilers.			
	Boiler A.	No 1.	No. 2.	No. 3
Square feet of water-heating surface	4000	4340	4800	4800
Square feet of steam-heating surface	383	....	....	....
Horse-power, standard rating	400	434	480	480
Horse-power, maker's rating	400	570	645	645
Horse-power developed	442.8	431.5	564.3	580.4
Horse-power developed above standard rating	10.7%	....	17.6%	20.9%
Horse-power developed below standard rating	....	.06%	....	....
Horse-power developed below maker's rating	....	32.1%	14.3%	11.2%
Length of travel of gases in contact with tube-heating surface, feet	21	13	13.3	36
Temperature of escaping gases, F. degrees	480.2	650.5	657	469
Temperature of escaping gases above saturated steam	127.8	273.1	278	92
Temperature of escaping gases above air supply	407.9	580.2	582	394
Temperature of saturated steam	352.4	377.4	379	377
Temperature of superheated steam	455.8	....	....	....
CO_2	9.22	7.93	10.7	10.3

Table I contains the essential data concerning the boiler trials. Boilers *A* and No. 1 are practically of the same size, although the horse-power of the latter is rated by its maker 31.3 per cent above the former. The horse-power developed above that of No. 1 by boiler *A* is 10.76 per cent and its CO_2 is higher, but, owing to unburned volatile combustible equal to 8.79 per cent of the total combustible, the condition of combustion is less favorable for this boiler than appears from the CO_2 measurement. The conditions for these two boilers may, therefore, be considered the same, except that with *A*, the saturated steam temperature was 25 degrees lower; for this reason its final temperature has been raised that amount, so that the comparison shall be on the same basis. In the case of boilers Nos. 2 and 3 the combustion was complete. With No. 2 the air supply and horse-power were slightly less, giving it a small advantage over No. 3.

Conditions of operation being the same, the difference of cooling effect is shown by the difference in final temperature measured above that of the air supply; this referred to the initial temperature, also above that of the air supply, determines the efficiency of the boiler. Figure 1 illustrates the relative efficiency of the four boilers that are being considered. The initial temperature is shown through a range that covers all attainable conditions. From an inspection of the curvés, it appears that the efficiencies of boilers Nos. 1 and 2 fall upon the same line, and that of *A*, which varied from the furnace temperature, is from about four per cent at 4000 degrees to 20 per cent at 720 degrees above the efficiency of Nos. 1 and 2, while No. 3 is more efficient than that of *A*. If, however, it is assumed that Nos. 1 and 2 discharge their gases through an economizer that would reduce the temperature by 200 degrees, then the efficiency of the combined boilers and economizer will fall on the same line with that of the efficiency of No. 3 without an economizer.

The efficiency curves are based on the final temperature being constant through the full range of the initial. To what extent this is true is shown by Fig. 2, which illustrates the relation between initial and final temperature, the curve being plotted from simultaneous measurements. It appears that within usual working ranges the final temperature remains quite constant. The value of the relative efficiencies from the standpoint of fuel saving is quite important. It is shown in Fig. 3; the efficiency of boilers Nos. 1 and 2 being taken as the standard. The value of an efficient boiler when served by an inefficient furnace, is forcibly illustrated.

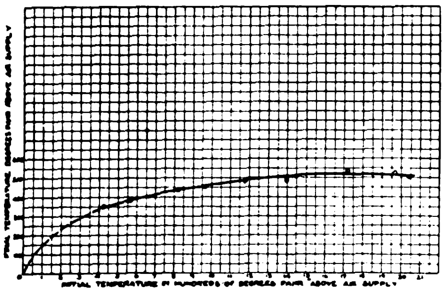

FIG. 2.—RELATION OF FINAL TO INITIAL TEMPERATURE.

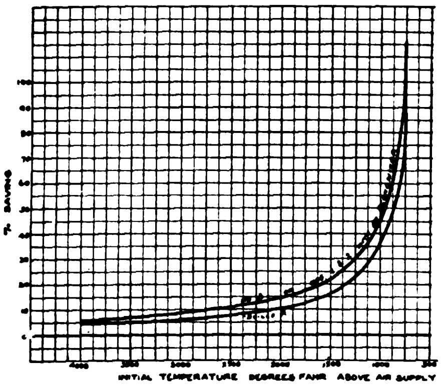

FIG. 3.—CURVES OF RELATIVE EFFICIENCY.

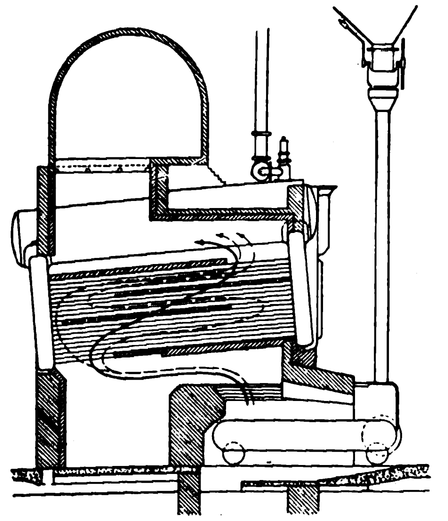

FIG. 4.—SECTION OF BOILERS.

The boiler and furnace of type *A*, having no special features, are not shown, but Fig. 4 is a vertical longitudinal section illustrating boilers Nos. 1, 2 and 3. The heavy arrow shows the path of the heated gases through Nos. 1 and 2. The travel in No. 3 is shown by the dotted arrows. The two baffles added in this boiler are indicated by the horizontal dotted lines; the lower of these was located so that between its ends and the back water leg there is a space of four inches left open for the full width of the boiler, to allow dust to drop down to the chamber below. Owing to this opening, the gas travel is split into two parts, a minor portion taking the more direct and shorter route by way of this opening, as shown by one of the dotted arrows, so, in fact, the effect on the hot gases of the three passes is not entirely secured. Fig. 5 illustrates a section of the tiles which encircle the lower row of tubes and provide a tile roof to the furnace extending beyond the bridge-wall. The application of these tiles was devised by Mr. W. L. Abbott for reasons that will be discussed later. Fig. 6 shows the tiles which close the spaces between the lower row of tubes back of the encircling tiles. They are those regularly supplied by the maker of the boiler, and leave the lower half of the tube exposed to the passing hot gas and are usually known as the T tile.

Table II gives in detail the performance illustrated in Fig. 7, which is a curve of temperature drop through the surface of boiler *A* plotted from measurements taken during the trial. From this it appears that the same length of travel in the last pass gave only 6.7 per cent of the cooling effect of the first pass, illustrating the importance of the gases being in contact with the heating surface for as long a period as practicable if large cooling effect be secured. Figs. 8 to 11 show measurements taken among the tubes of boiler No. 2 and also apply to No. 1. Fig. 8 shows prevailing temperature among the tubes 45 inches back from the water leg, from the bottom to the top of the boiler. The measurement at the first, or lowest, stay-bolt, shows the effect of the heat from the tile roof immediately over the fire. The minimum temperature is between the second and third stay-bolts; above this it rises until at the point of escape the maximum is reached, showing that on the line of the measurements the highest temperature is at the point of exit. The drop of the ninth measurement is owing to the sudden change in the path of gas travel over the end of the baffle at the top of the boiler, which causes the hottest point to be carried back slightly more than 45 inches at this ninth stay-bolt.

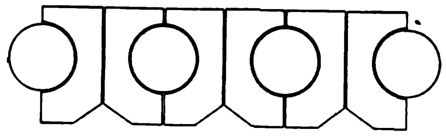

FIG. 5.—SECTION OF TILES.

Table II.

Temp. initial	2012° F	
Temp. at end of 1st pass...	908° F	
Temp. at top of 2nd pass. ..	680° F	
Temp. at bottom of 3rd pass	555° F	
Temp. at final	480.2°F	
Drop in temp. first pass	1107°F	72.064%
Drop in temp. drums	158°F	10.29%
Drop in temp. superheater ...	70°F	4.59%
Drop in temp. second pass ..	125°F	8.16%
Drop in temp. third pass	75°F	4.896%
Total	1532°F	100.000%
H.P. developed in first pass	321	
H.P. developed in drums	44	
H.P. developed in superheater...	20	
H.P. developed in second pass ..	35	
H.P. developed in third pass	22	
Total	442	

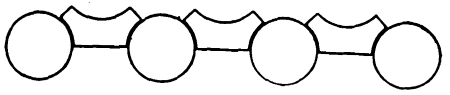

FIG. 6.—ARRANGEMENT OF TILES.

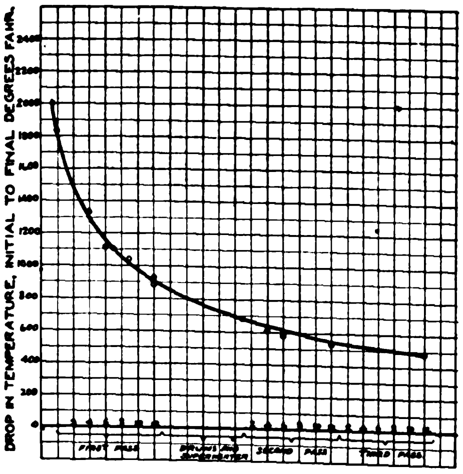

FIG. 7.—DROP IN GAS TEMPERATURE.

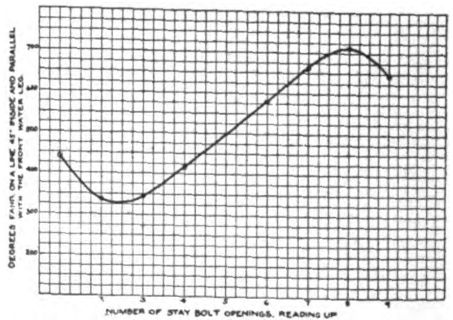

FIG. 8.—TEMPERATURE CURVE.

Fig. 9 is a curve from measurements taken through the ninth or top stay-bolt on a horizontal line, across and beyond the path of the gases at the exit from the tubes; the highest temperature is found at a point 46.5 inches back from the inside face of the water leg. From this point in each direction there is a rapid drop as the distance proceeds.

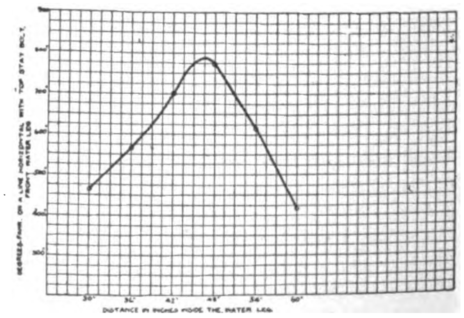

FIG. 9.—TEMPERATURE CURVE.

In Fig. 10 one of the curves shows the percentage of carbon dioxide in the gases on a line 30 inches inside and parallel with the front water leg of boiler No. 2. It will be observed that the measurements in the lowest part of the front of the boiler are extremely low; the first two, however, show the effect of leakage through the furnace roof. The contrast between boilers Nos. 2 and 3 in this respect is remarkable. As analysis showed the CO_2 to be low on account of the presence of air, it is proof that this air must have entered by leakage, and as such leakage could not be very large it follows that the path of the gases does not extend to the front lower corner of the boiler, or along close to the front water leg. This may be considered proven by the curve of CO_2 from boiler No. 3, subject to the same leakage, but with an arrangement of baffles which caused the flow of the gases to be carried into the front lower corner and nearer to the front water leg. It is further illustrated by Fig. 11, giving CO_2 measurements across the path of the gases at the exit from boiler No. 2, showing that the CO_2 increases with the distance away from the water leg. From measurements made through the back water leg of boilers Nos. 1 and 2, it is shown that a similar condition to that in the lower front corner existed in the upper back corner of the tube surface, but on a reduced scale, showing that with these boilers the back upper corner performs a small amount of work and the front lower corner still less, also that the active portion of the heating surface is on a diagonal line from the lower back to the front upper corners. It shows further that the volume of the moving gas body is of decreasing magnitude as it proceeds, and that as its center is approached the temperature is higher, so it is probable that its center is moving at a much higher velocity than its surface. According to Fig. 9 it would appear that the greater portion of gas was flowing through the space of one foot at the front end of the top baffle, and if an opening four feet long from the furnace at the lower back corner is large enough, it would follow that a space considerably less at the outlet would answer.

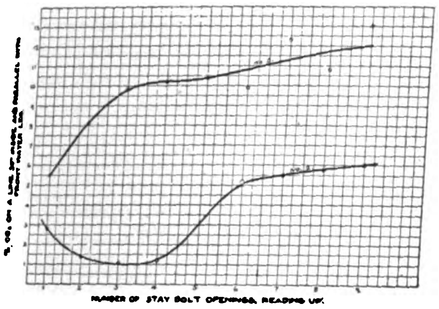

FIG. 10.—CARBON DIOXIDE PERCENTAGE CURVES.

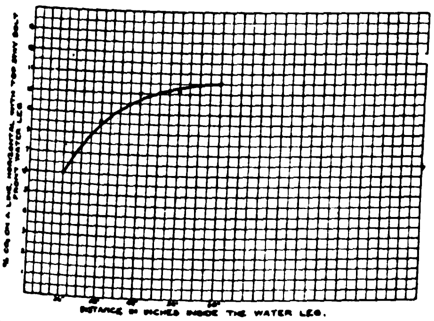

FIG. 11.—CARBON DIOXIDE PERCENTAGE CURVE.

As the volume of gases decreases rapidly with drop in temperature, it is probable that boiler *A* would be improved by passing the gases across it four times in passages of properly proportioned size, not adding to the amount of heating surface, but bringing more of it into active use; because with this boiler, as with Nos. 1 and 2, the tendency is for the gases to flow in a narrow path diagonally across the tube surface of the pass.

It is apparent that the greater efficiency of boiler *A* as compared with No. 1 is not owing to difference in amount of heating surface, but to greater length of travel of the gases in contact with the same amount of surface, or, in other words, greater length of time for the transfer of heat. This is still better illustrated by boilers Nos. 2 and 3.

The efficiency of the *A* type as compared with that of Nos. 1 and 2 is based on this particular type, which is a high "double-deck" apparatus, and it does not follow that a lower type would show such superiority. This may be illustrated by assuming that boilers *A* and No. 1 be each reduced one-half in height, when the effect would be that the length of the travel of the gases with *A* would be reduced 50 per cent, while with No. 1 the reduction would amount to less than 10 per cent; so, as the height is less, the efficiency of *A* drops off very much faster, and while the gain in the high No. 2 over the low No. 1 type is small, with that of *A* it is very large.

The initial temperature, or, in other words, the condition of combustion, has more effect on the efficiency of the steam-generating apparatus than has the cooling effect of the boiler. This is shown by the efficiency curves Fig. 1, and if choice lay between the two, that of high initial temperature would be chosen; but high initial temperature is always dependent on skillful manipulation of the fire, and its attainment is difficult and more or less uncertain, while the superior boiler efficiency has a fixed value not dependent on the skill of the operator, and this value increases as the initial temperature decreases. There might be some question as to whether the full value of a good furnace would always be realized, but there could be no failure to realize the value of an efficient boiler.

The most remarkable feature of this matter of boiler efficiency is that the simple addition of inexpensive baffles, with no labor cost for operation and requiring no additional room in the plant, gives results equal to an economizer requiring a large investment, considerable expense for maintenance, and a large amount of space for its installation.

The foregoing refers to the boilers only, and it is now in order to examine the furnace performance. The comparative test between *A* and No. 1 gave the following relation between the two apparatus:

	A.	No. 1.
1. Efficiency of combined boiler and furnace	57.83	59.12
2. Efficiency of boiler	77.69	70.12
3. Superior efficiency of boiler	7.57	
4. Superior efficiency of furnace ...		8.86

Item 1 includes all losses except that of combustion in the refuse, all other losses except hot gases and combustion being the same for each apparatus. Item 2 is the measure of the cooling effect produced by each boiler. Item 3 is the difference in the cooling effect produced by the two boilers. The superiority of the furnace under boiler No. 1, Item 4, is owing to better combustion, there being a loss of 8.86 per cent with the furnace of the *A* boiler, due to escaping hydrocarbons and incomplete combustion, the air supply being considered the same in each case. The reason for the difference in combustion with these two furnaces will be understood when each is examined in detail. The furnace under the numbered boilers will hereafter be referred to as the tile-roof furnace, and the other as the *A* furnace; the former is shown in elevation by Fig. 4; the roof is made with tiles shown by Figs. 5 and 6. The distance from the coal gate at the front of the furnace to the end of this tile roof is 16 feet, a distance through which the gases must travel before coming in contact with the boiler surface except in the lower half of the bottom row of tubes, which for a distance of about four feet back of the bridge-wall are exposed as shown by Fig. 6, there being a distance of travel of 12 feet with no cooling effect, except that of radiation from the exterior furnace walls and through the tile roof. During the interval of time that the gases are moving through this distance of 16 feet their mixture is proceeding, so that before they have reached a point among the tubes where the temperature has dropped to a point below which union will be effected, the mixture is completed; or, as more generally understood, complete combustion is effected.

With the *A* furnace the gases from the fire rise immediately and pass among the tubes of the boiler. There being not to exceed three feet in distance for the gases to travel before the tubes of the boiler are reached, the temperature soon drops to a point at which chemical union does not take place; the result is an escape of unoxidized combustible in the form of hydrocarbons, carbon monoxide and free carbon.

The theory of the action of the tile-roof furnace may be given as follows: The coal entering at the front of the furnace has its volatile matter rapidly distilled in the form of a hydrocarbon gas in excess of the air supply at the front of the fire, and flowing back meets a larger air supply from the back of the fire, where the fuel bed is thinner. With this it mixes, the excess of air from the back satisfying the deficiency at the front; and being thoroughly mixed in the chamber below the tile roof, it becomes, strictly speaking, a product of combustion at high temperature, which carries its heat from the furnace to the boiler. Assuming that the action of this furnace is as described, it would appear possible to obtain complete combustion with no air in excess; the indications are that this is possible. With one of these furnaces carefully worked and with the draught pressure at a certain determined intensity, it was possible to maintain an average as high as 17 per cent CO_2, and for a few short intervals obtain as high as 19 according to the econometer connected to the furnace. There was no opportunity to test this condition with analysis, however, owing to the short duration of the intervals, but the econometer checked very closely with analysis at lower ranges. With the extremely small air supplies as given here, if the feed of coal was increased, it was accompanied by a raise in CO_2 to the apparent theoretical maximum, after which it fell, owing, presumably, to carbon being oxidized to carbon monoxide, but there appeared to be no tendency for carbon to be set free.

With the *A* type chain-grate stoker and boiler, or similar boilers and furnaces, the gas distilled at the front of the fire flows directly among the tubes, and results in loss by unburned hydrocarbons and free carbon, the latter making smoke, while the large excess of air from the thinner back end of the fire also flows directly among the tubes, but at a different point, and there is but poor mixture. With such a furnace, the smoke and loss of hydrocarbons will drop off with increased excess of air, owing to a stronger draught; but the loss from this increased excess of air is greater than the combustion gain, therefore best efficiencies are to be obtained with the smoky condition.

The above, concerning the three types of boilers and two kinds of furnaces under discussion, may be followed by an examination, as far as present knowledge will allow, of the single type of stoker that is to be considered. This is the chain-grate, and the one that is the nearest approach to an automatic machine; but in practice it is decidedly unsatisfactory so far as efficiency is concerned. The best performance secured with these stokers in the tile-roof furnace boilers is as follows:

	Example 1.	Example 2.
Efficiency	72.0	69.8
Pounds of water evaporated per hour per sq. ft. of heating surface	4.1	6.07
H.P. per sq. ft. of grate	6.13	11.6

From these examples the efficiency has ranged down to 40 per cent and capacity in proportion. The size of the coal used has an important effect on capacity—all other conditions being the same—and may affect the result as much as 60 to 80 per cent.

The greatest fault thus far recognized in chain-grate stokers is the air leakage into the furnace at the back end of the grate. This and loss of combustible in the refuse are its major faults. With the grate as usually made and installed, an effort to prevent fuel being discharged over the back end by running short fires, is accompanied by an increase of the excess of air that often overbalances the fuel saving. The entrance of air at the back end of the grate is, strictly speaking, a leakage; its entrance is by way of openings at the side of the stoker, between the top and bottom chain and under the traveling grate, and into the furnace by way of the opening between the bridge-wall and the end of the grate. For this leakage at the back of the fire there are two remedies; one is to make the opening for the discharge of refuse only large enough to allow the ash to pass out, and keep the end of the fire in contact with the bridge-wall. This opening may be restricted by building the brick bridge-wall the required distance above the grate, or by building into the point of the wall a metal box or pipe through which water circulates for the purpose of keeping it cool. The disadvantages of the brick wall are that the clinker readily adheres and makes trouble, and that the life of the brick at the lower edge is very short, requiring frequent and expensive renewal. The size of the opening is a matter that is necessarily unsatisfactory, because the amount of ash in the coal will differ and the opening must be large enough to accommodate the largest amount, consequently being too large when ash is low. The performance designated as example No. 1 was obtained with the brick wall described, and owing to an extremely large amount of ash in the coal the effect was to close the opening at the end of the grate largely with ash rather than with fuel, resulting in a comparatively small loss to the ash pit. Of these two means for keeping the air from leaking into the furnace by maintaining a joint between the end of the fire and the bridge-wall, the water-back is the most satisfactory.

The other method of stopping air leakage at the end of the fire consists in closing the openings at the sides of the stoker frames, between the bottom chain and the floor under the stoker, and between the upper and lower chains. With this scheme the air leakage is avoided without keeping the fire against the bridge-wall. It was with this method that the performance designated as example No. 2 was obtained; the large capacity was owing to the use of washed coal from the Wilmington district of Illinois. At the present time the best means to offer for the remedy of the faults at the back end of the fire is to seal off the leaks as mentioned in the second method, and the use of the water-back located as close to the grate as practicable. The latter performs an important office, inasmuch as it is an insurance against carelessness in running the fires over the back end of the grate.

The foregoing has treated only of the excess of air coming from the back end of the grate, but it does not entirely cover the subject of excess of air. With the furnace of the *A* type, 12 per cent CO_2 is about the maximum under any condition. This is also true of the tile-roof furnace unless the fire is so operated that a considerable excess of volatile combustible is evolved at the front end of the fire and mixed with the excessive air from the thin fire at the back. But the evolution of an excess of volatile combustible requires either a thick fuel bed or a low draught, and it appears that the thickness of fuel bed and strength of draught are features of importance.

With chain grates as generally installed and operated, all other conditions being the same, a reduction in the draught over the fire results in increased efficiency and reduced capacity. On the other hand, an increase in draught over the fire increases the capacity but reduces the efficiency. In the plant mentioned as having the tile-roof furnaces, draughts over the fire range from 0.15 to 0.45 in inches of water, but the attainable depth of fire, height of coal in the hopper and speed at which the grate travels, are the same for each strength of draught. It is entirely reasonable to assume that if 0.15 is strong enough, 0.45 is too strong; likewise that if 0.45 is right 0.15 is too low; and it is apparent that the dimensions of the stokers and the various draughts are not in proportion to each other. In this plant the high efficiencies are always obtainable with the lowest draughts, and the highest capacities with the strongest draughts.

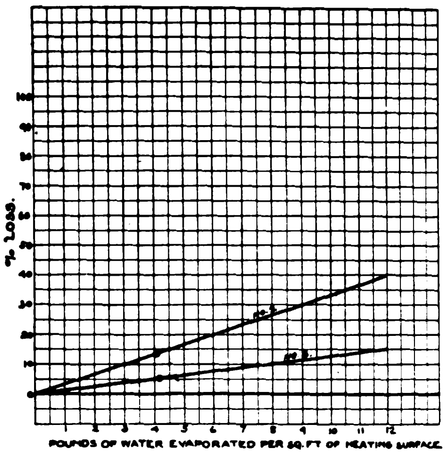

FIG. 13.—CURVES OF BOILER LOSSES.

It is the general tendency to seek a strong draught over the fire with chain-grate stokers, and for this purpose induced mechanical draught apparatus and tall chimneys are employed; but suction draughts may be so strong as to cause such an excess of air to flow through the coal in the hopper as to prevent the fuel from igniting. It is possible that a moderate suction above and a pressure above atmosphere under the fire will give the most satisfactory results when large capacities are required.

Loss of combustible in the refuse with chain-grate stokers has been observed as low as one per cent. With the tile-roof furnace, complete combustion with little or no excess of air has been secured, and if such desirable furnace conditions are combined with the performance of boiler No. 3, it will make an important improvement over the best prevailing practice. It is

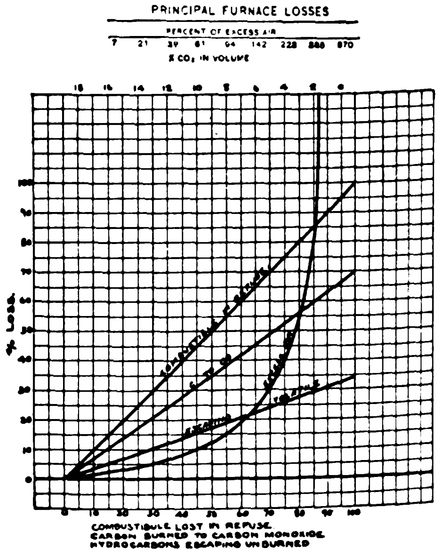

FIG. 14.—CURVES OF FURNACE LOSSES.

probable that this is the most efficient boiler of which there is any record. About the highest efficiency reported is that of a Thornycroft boiler by Professor Kennedy, showing 86.8 per cent of the heat absorbed when evaporating 1.24 pounds of water per square foot of heating surface per hour with a condition of combustion about the same as that with No. 3; under these conditions the gases left at 41° Fahr. above steam temperature. With, however, an evaporation of 3.2 pounds of water per square foot of heating surface and a somewhat better combustion, the gases left at 165° Fahr. above steam temperature. In the case of boiler No. 3 the gases left at 92 degrees above steam temperature when evaporating 4.17 pounds of water per square foot of heating surface. No. 3 is a more efficient boiler than *A*, but owing to its design, there is no favorable location for a superheater. With the *A* type, the design affords an excellent location, which is sufficiently removed from the excessive furnace temperature, and at a point where it is high enough to ensure the desired effect.

There is one feature of the tile-roof furnace previously mentioned, which is of considerable importance. It is the protection afforded to the lower row of tubes of the boilers designated as Nos. 1 to 3. It has been the maker's practice to use the tiles shown by Fig. 6. This leaves one-half of the bottom row of tubes exposed to the full furnace action; it does not matter that there are many hundreds of feet of surface in the boiler above, because the gases do not come in contact with this surface until after leaving the furnace. As with an economizer, the boiler is heated first. Applying this illustration to the surface exposed to the fire, the 110 square feet over the furnace may be assumed to be the boiler surface. This would mean that there are about 1½ square feet of heating surface per square foot of grate; the result is that the tubes in the bottom row become blistered, bent out of line and fail, owing probably to the area of the tubes not affording sufficient water supply. But with the tiles in place, the tubes in the lower row remain as straight and in as good condition as those in the uppermost row.

In concluding this paper, it will be interesting to make a comparison of the principal losses that occur with boilers and furnaces. For this purpose Figs. 13 and 14 have been prepared. These diagrams are designed to show the relations that these individual losses bear to each other, and these would be best shown by one diagram if it were not for the complication of a large number of lines in one chart. For this reason the boiler loss is shown in Fig. 13 and that of the furnace in Fig. 14; with the former the performance of boiler No. 3 is selected to represent the loss owing to decreasing cooling effect with a very efficient boiler, and No. 2 for a much less efficient boiler. The zero of loss is taken at the steam temperature, because below this point no further cooling of the gases can take place; the range of capacity is carried up to the evaporation of 12 pounds of water per square foot of heating surface per hour, and the location of the lines is governed by the performance of the two boilers in the tests before mentioned. These two losses are represented as straight lines, which is not entirely correct, because as such they will intersect the line of 100 per cent loss if capacity be carried far enough, but a boiler could never be driven so hard that its efficiency would become zero. The representation by straight lines is sufficiently correct, however, for the purpose in hand.

Referring to Fig. 14, the losses owing to combustible in the refuse, carbon burned to carbon monoxide, and to escaping volatile combustible, are each carried to the theoretical maximum. It is, of course, impossible that all of the volatile matter could escape unburned; or that all of the carbon could be oxidized to carbon monoxide, as this is unattainable even in a gas producer. Neither would it be possible for all of the combustible to be lost in the ash pit, because then there could be no fire. But it is useful to ~~represent these~~ three losses through this entire range for purpose of comparison with that owing to excess of air. The calculation of the loss of escaping volatile matter is based on Pittsburg coal. The curve of excess of air is based on a final temperature of 550° Fahr. and a combustible of 14,000 B.T.U. per pound.

As mentioned, the combustible losses can never be as high as 100 per cent, but the loss by excess of air can be as high as that, because with a small fire and large enough air supply, the initial temperature may be as low as that of the boiler. For this loss to be over 100 per cent, however, requires that stored heat from brickwork and furnace walls be given up to the air and gases in the furnace in addition to the heat from the fuel; such loss can exist for only a short time because the brickwork would soon become cooled. But that it is possible is proven by measurements showing a final temperature of 520° with 1 per cent of CO_2.

[The foregoing is a paper read at the recent convention of the National Electric Light Association held at Chicago.]

Abstracts from Foreign Contemporaries

Power Factor Indicator. – The London *Electrician* describes a direct-reading power factor indicator, the design of which is based on the known fact that when two wattmeters, suitably connected, are employed to measure the power on a balanced three-phase system, the ratio of their readings varies with the power factor of the system. The arrangement is illustrated in Figs. 1 and 2. If the two wattmeter movements are mounted with the moving coil on one axle, and the axes of the fixed coils at a suitable angle, the moving coils being perfectly free to turn without any control, and connected as shown, the moving coils will take up a position proportional to the phase angle. As the system is assumed to be balanced, the currents in the three line wires are equal, and it is, therefore, necessary to have only one moving coil. *B* and *D* are two fixed coils of wire wound in annular grooves in the insulating former, *C*, which have their axes inclined at a suitable angle, *A*, according to the length of scale required for a given power factor, and are so wound that their magnetic fields are equal. The moving coil, *E*, is free to turn without any control, the electromagnetic forces being so large that friction, etc., is negligible. With a unity power factor the moving coil sets itself into the position where the forces exerted by the two fixed coils are equal; that is, midway between the coils *B* and *D*. In this position the pointer indicates 1 in the center of the scale. If the amperes are lagging behind the volts, the fixed coil, *D*, exerts less force on the moving coil than the fixed coil, *B*, and the moving coil is, therefore, drawn over to the coil, *B*, until the two forces are again balanced. Thus, on a lagging power factor of 0.5, the free coil, *E*, will be co-axial with the fixed coil, *B*, and the pointer will indicate 0.5 lag on the dial. The instrument is made dead beat by means of a damping disc carried by the moving coil, *E*, and moving between the poles of a permanent magnet.

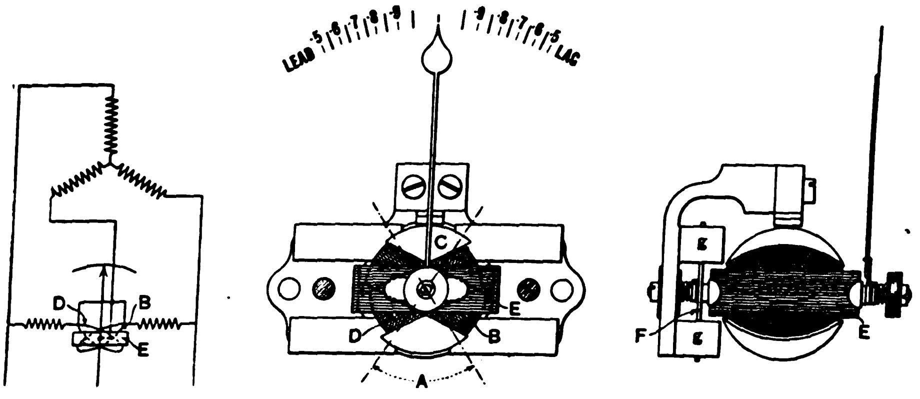

FIG. 1.—POWER FACTOR INDICATOR.—FIG. 2.

Operation of Arc-Light Systems.—Operating engineers are always seeking for ways of reducing the cost of operating electric stations, and particularly that of producing the current. Herr R. Herzog calls attention in a recent issue of the *Elektrotechnischer Anzeiger*, to a neglected phase of operation, which is the careless use of the carbons. With the price of current at 20 pfennigs (5 cents) per kilowatt-hour, the cost of carbons is about 15 per cent of the total cost of operating the lamps. In larger stations, where the cost of operation is proportionally less, the cost of the carbons may be 18 per cent. In order to use the carbons most economically, they should be made in lengths proportional to the hours of lighting. Another point which has been neglected is the use of carbons of different diameters. The volume of a carbon is proportional to the square of its diameter, so that this should vary with the length of the carbon. There are limits, however, which should not be passed. The low limit for the large carbons is that where hissing is produced by the short arc. The upper limit for smaller carbons is where flickering begins. A graphical construction gives a simple way of determining the proper length of carbon for any time of lighting. The co-ordinates of the diagram are length of carbon and hours of lighting. A certain constant minimum length of carbon must be assumed to prevent burning of the holders. Then, by experiment, the consumption for different diameters can be determined, and by laying these off on coordinate paper, and drawing lines through points thus determined from the assumed minimum length, the proper length of any size of carbon for any time of lighting is easily determined. In this way the waste of carbon should be reduced to a minimum. A difficulty in this method arises because arc lamps are usually manufactured for only one size of carbon; but by using an adjustable holder, this difficulty is overcome.

Properties of Gutta-Percha.—A recent issue of *L'Electricien* contains an interesting discussion of those properties of gutta-percha, which make it valuable in electrical applications. At ordinary temperatures, gutta-percha is as durable as wood. It is flexible and as tenacious as leather; at temperatures from 100 to 500 it becomes plastic and capable of being moulded, and upon being cooled it returns to its original condition. The temperature at which it may be worked, depends upon the purity of the material. Good gutta-percha should not become plastic until it has reached seventy to seventy-five degrees, while the presence of certain adulterants causes it to become soft at thirty-five degrees. The purer the material, the more quickly does it regain its original position. Low temperatures do not affect it. Density of the material varies with its purity, pure gum having a density approximately equal to that of water. Its electrical properties vary with its purity. A thickness of one millimeter of good material can stand 16,000 volts. It is not soluble in water or alcohol, although the resines used in adulterating it are. This suggests a method of purification. It is, however, soluble in carbon bisulphide, chloroform and toluene. With heat, it may be dissolved by turpentine, certain oils and benzine. It resists the action of all acids except concentrated sulphuric and nitric. When exposed to the air, it deteriorates slowly, but lasts indefinitely under water. Methods are given for analyzing the material and for determinig the purity. The pure gum consists of three chemicals; one a hydrocarbon and the other two oxides of this hydrocarbon. It is suggested that the original gum consists of the hydrocarbon alone. A good quality of gutta-percha contains sixty-five per cent of the pure article.

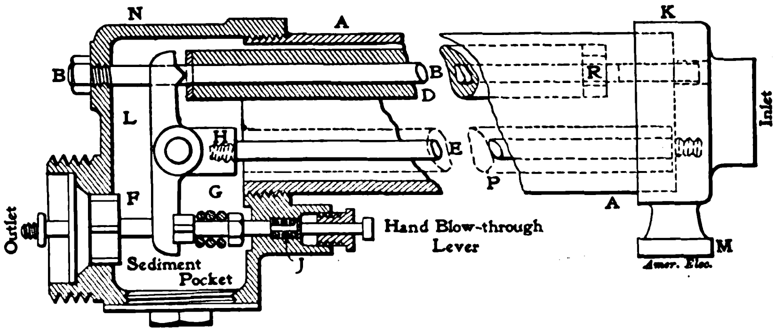

FIG. 3.—COMPOUND EXPANSION STEAM TRAP.

Compound Expansion Steam Trap.—In expansion steam traps the movement of the valve is due merely to the difference in the rate of expansion of two metals or alloys, hence the greater this difference the greater will be the efficiency of the trap. Hitherto, steel and brass have been practically the only metals available for the construction of nearly all the ordinary designs of these traps, but as the rates of expansion of these metals are in the ratio of about seven to ten, it is obvious that 70 per cent of the expansion of the brass is ineffective, it being lost or wasted, owing to the simultaneous expansion of the steel. In order to compensate for this great loss, it has been customary either to place the steel at a distance from the body of the trap, to prevent much heat reaching it; or to have recourse to multiplying levers and other "gearing up" devices, which multiply the effective expansion—by the time it reaches the point of operating the valve—seldom less than ten times, and often to a much greater extent. Taking the former ratio, it is clear that the strain upon the expansion tube must be ten times greater than the total pressure on the valve, or, for example, with a 1-in. valve and a working pressure of 150 lb., the expansion tube will be subjected to a thrust of fully half a ton—a strain which certainly cannot promote sensitive action, and which, together with the known weakening of brass when heated beyond a moderate temperature, may to a great extent account for the rather unfavorable manner in which expansion traps are regarded by some engineers. Fig. 3 taken from the London *Engineer*, illustrates an entirely new expansion steam trap, the efficiency of which is greatly due to the employment of a recently-discovered alloy containing about 36 per cent of nickel, and 64 per cent of steel, which has the remarkable property of being almost unaffected by thermal changes. Stated accurately, its expansion is about ten times less than that of steel, and thirteen to fourteen times less than that of brass. It should be noted that in consequence of the very low expansion of this nickel steel alloy, it is now possible to construct an expansion trap of steel, and therefore one that will stand very high temperatures, such as 600° to 700° Fah., and also very high pressures. Referring to the illustration, the exterior *A A* and the tube, *D*, are of brass in the low-pressure and of weldless steel tubing in the high-pressure type. The nickel steel rod, *E*, is at one end rigidly fixed to the end, *K*, of the trap, and its other end carries the fulcrum of the lever, *L*. Owing to the very slight expansion of this rod, *E*, the lever fulcrum remains practically in a constant position at all temperatures. A second nickel steel rod, *B*, is fixed to the left-hand end of the trap and carries the tube, *D*—butting on the nut, *R*—so arranged as to thrust against the top end of the lever. When the trap becomes heated by the presence of steam, the exterior casing—including the valve-box, *N*—expands, carrying the rod, *B*, to the left, and with it the tube, *D*, which consequently thrusts the lever to the left; but meanwhile the tube, *D*, has also expanded, hence the lever is operated by the combined expansion of *A A* and *D*, and the valve, *F*, has a corresponding travel, but in the right-hand direction towards its seat. Now it will be observed that as the valve seat is rigidly connected to the casing, *A A*, the expansion of the latter causes the seat to move towards the valve, consequently the seat and valve approach each other, their respective movements being in the ratio of about one to two. When water enters the casing, *A A*, and tube, *D*, become cooler, and contracting, allow the valve to open, whereupon the water is ejected. It will be observed that there is no multiplying gear in this design, the whole action being direct and all the parts are subject only to direct tensile and comprehensive strains. The trap, too, is so proportioned as to give a full-way opening when cold—that is to say, the area through the open valve is equal to that of the trap's inlet, and consequently large volumes of water can be rapidly blown through when starting with the pipes, etc., in a cold state. This full way occurs when working with pressures of about 70 lb., but with higher pressures the opening is of course more than a "full way." Another point of great convenience is that the valve can be removed or replaced in a few seconds—the cross head on the valve stem being so arranged as to pass through the forks of the lever, *L*, when it—the cross head—is turned through one right angle—the turning being effected by the milled rim on the extreme left of the valve stem. With regard to the loss of strength in brass, it is well known that at temperatures beyond about 300° or 350° Fah. the metal becomes so weak as to be unreliable, hence for steam traps working at beyond about 120 lb. pressure it would seem desirable, if not imperative, to entirely avoid brass and substitute either iron or steel, and the inventor, W. A. Granger, claims superiority for "all steel" traps for high-pressure and for superheated steam. The lesser expansion of steel, of course, reduces the effects in the ratio of about seven to ten as compared with brass traps, but this is corrected by constructing the lever, *L*, so as to multiply the action about one and one-half to one—the steel tubes being well able to stand the extra strain.

Reversible Booster.—In an illustrated descriptive article on the South Lancashire tramways, the London *Electrician* describes a reversible booster of special construction and capable of working at 240 amperes and 130 volts when the battery is being charged and 70 volts and 576 amperes when the battery is discharging. The reversible boosting process is carried out automatically in accordance with the requirements of the service, the arrangement being shown in Fig. 4. The booster armature is in series with the battery across the bus-bars, and the reversal of e.m.f., together with the regulation of the pressure to the correct amount in either direction, is effected by means of a regulator, consisting of a regulating resistance for the shunt field of the booster, in conjunction with a reversing switch, both of which are operated by a small auxiliary electric motor. The motor runs continuously in one direction and drives a mechanism which cuts out and reverses or introduces resistance into the field of the booster, the speed and the reversing being controlled by means of a solenoid, which is governed by the bus-bar voltage. Thus, for instance, the contact arm of the shunt resistance in the booster field circuit moves in one direction and introduces resistance into the booster field circuit, then at a certain point in its travel it reverses the connections on the booster field, and cuts out resistance as required, in order to keep the bus-bar voltage constant. This varies the strength of the booster field in either direction, and assists or opposes the battery current, in accordance with the requirements of the external load. The rate at which this arm travels over the contacts is extremely rapid, the time taken to move completely around the dial, i. e., from the maximum charge in the battery to the maximum discharge, being something like 15 to 20 seconds. The particular direction of rotation of this arm is governed by the solenoid through a simple trip mechanism.

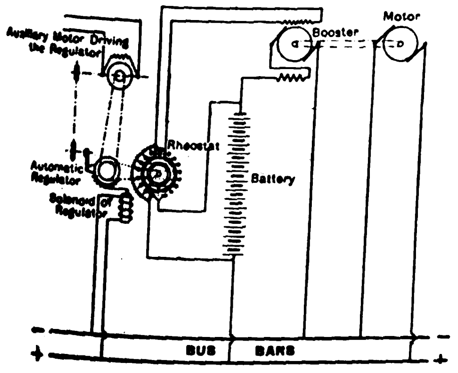

FIG. 4.—DIAGRAM OF BOOSTER CONNECTIONS.

Sirius High-Efficiency Lamp.—A recent issue of the *Elektrotechnischer Anzeiger* contains a description of the Sirius high-efficiency lamp, a type of incandescent lamp which gives a high economy, on account of the peculiarities of the filament. As yet, the lamps have not a long life, and the efficiency changes but little during use. The light given by this lamp is considerably whiter than that of the ordinary incandescent lamp, standing in this respect between the latter and the Nernst lamp. The cost of the Sirius lamp is about the same as that of the incandescent lamp. It is not particularly sensitive to changes in voltage. The author of this article gives the results of tests carried out upon ten 110-volt 16-c.p. lamps of this make. In order to obtain practical conditions, the supply was interrupted every eight hours, and the lamps were allowed to stand idle for one or more hours. Measurements were made every thirty hours, of current, potential and illumination. The results are given in three curves showing the average results, the dotted curves showing average results obtained from ordinary incandescent lamps. During 200 hours of burning, the average candle-power fell from fifteen candles to a little less than ten. The average watts per candle rose from 2.3 to 3.6. Current fell during the same time from 3.4 to 0.3 ampere. One of these lamps burned out within 100 hours, but the average life was about 160 hours. The short life obtainable at present deducts considerably from the efficiency, but it is thought that the lamp will be improved in this regard.

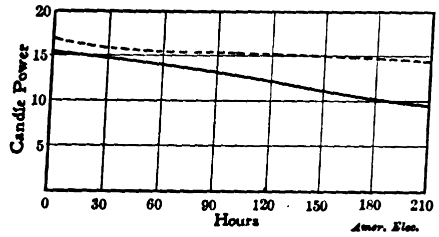

FIG. 5.—CURVES OF CANDLE-POWER.

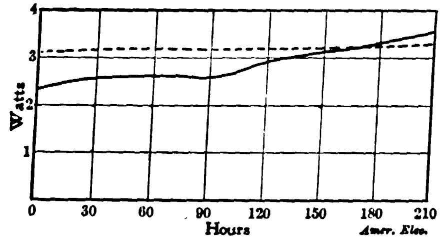

FIG. 6.—CURVES OF WATT CONSUMPTION.

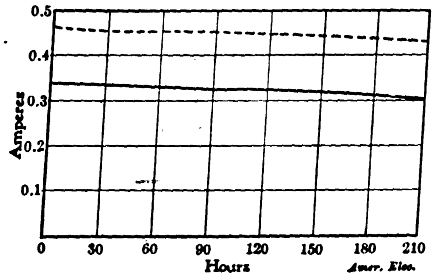

FIG. 7.—CURVES OF CURRENT CONSUMPTION.

Combined Reducing and Safety Valve.—The accompanying illustrations (Figs. 8 and 9) taken from the London *Engineer*, show a simple combination of reducing and safety valves, the principle of action of which is both novel and ingenious. The course of the steam through the valve is indicated by the arrow, the high-pressure steam entering at *C*, and the reduced pressure issuing at *D*. The working of the valve is as follows: The valve, *A*, is connected by a spindle with the bottom of the box, *H*, which forms a receptable for a tube, *E*, formed of india rubber, which rests in the bottom part, as shown, and is also accommodated in a similar cavity in the bottom end of the gilled extension, *G*. This tube, *E*, is reinforced on the outside by a series of rings, *J*, loosely slipped on. The effect of this combination is that the tube is free to stretch in the direction of its length, but remains constant in diameter. It is found in practice that if the external diameter of the tube, *E*, or the inside diameter of the rings, *J*, which is the same, is made exactly the diameter of the seating appertaining to the valve, *A*, the latter is in equilibrium at any pressure acting in the direction of the arrow, which in this case is the initial pressure. The box, *H*, receives the upward pull of the springs, *L*, put into tension through the yoke, *M*, and adjusting screw, *N*. The pull on the springs will, therefore, disturb the equilibrium established as described and give the valve, *A*, a preponderance upwards, and

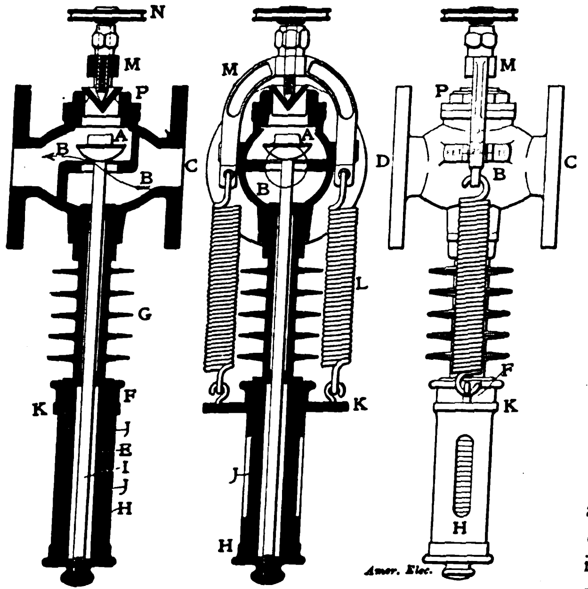

FIG. 8.—COMBINED REDUCING AND SAFETY VALVE.—FIG. 9.

the amount of tension will determine the reduced pressure. For instance, suppose the area of the valve, *A*, be one square inch and an upward pull of 10 pounds is exerted on the springs, as soon as the steam pressure on the top of the valve slightly exceeds 10 pounds, the weight will overcome the springs, and the india rubber tube will begin to stretch and allow the valve to close to its seating, and so prevent the further passage of steam. The india rubber tube with its surrounding rings is in effect an elastic cylinder, the bottom end of the casing, *H*, acting as a frictionless piston, the body of the cylinder itself elongating. The movement of the cylinder being divided amongst the rings, the rubber, even when extended, is supported so as not to be distressed. The pressure of the adjusting screw, *N*, is taken by the valve, *O*, seated in the cap, *P*. Now this valve is smaller in diameter than the valve, *A*, say by 20 per cent, and will lift if the pressure above *A* exceeds by this amount the predetermined pressure for which the valve, *A*, is set. The 20 per cent margin is, therefore, a constant ratio for all pressures to which the valve may be adjusted. The rubber tube is protected from the heat by being filled with water, and the conduction of the heat downwards is largely minimized by the gills, *G*.

Convention of the Independent Telephone Association.

The Independent Telephone Association of the United States at its convention, which was held in Chicago, at the Auditorium Hotel, June 24 and 25, made some radical changes in its organization and object, which put the work of the association on an entirely different basis from heretofore. Amendments to the constitution were adopted, which amounted to practically a new constitution, as Article I of the former constitution was the only one not amended. This article is the one specifying the name. The reasons for the desirability of a change amounting to almost a reorganization, were stated by S. P. Sheerin, of Indianapolis, in the presentation of the amendments. He said that the Independent Telephone Association of the United States in the past had almost as its sole purpose the defence of patent cases. That work was now successfully brought to a close, and there was no need of keeping up the association as a fighting organization. He thought, however, that the association could be changed into an organization of great benefit to the independent telephone industry along peaceable lines. The changes specified in the amendments to the constitution, which were unanimously adopted, vested the membership of the Association in individuals instead of companies, as heretofore. The initiation fees were placed at $2, and the annual dues at $1, with the idea of having every man interested in independent telephony join the association, especially the younger engineers, upon whom the future of the independent telephone business will depend. The association as now organized, is one for the exchange and dissemination of technical knowledge along the same lines as other local engineering bodies.

The first session of the convention was held Wednesday afternoon, June 24. Judge James M. Thomas opened the session by presenting the president's annual address. Judge Thomas said that in the six years that he had acted as president of the association, he had taken such an active part in its affairs that he was not in a position to stand back and act as a critic of what had been accomplished. He expressed his gratitude to the association for the six-year tenure of office which had been granted to him. He felt that at this time there was need for a reorganization of the association upon new lines, and that he should turn his duties over to other hands. The association had been criticized in the past as an organization with but one idea. He was glad of it. That one idea involved the very right of independent telephone companies to do business. Men must first establish their right to do business before they can do business. This the independent telephone interests of the country had done by virtue of the fight carried on by the Independent Telephone Association and as proof of this, he stated that there were more independent telephones in use in the United States to-day than there were Bell telephones. With the reorganization of the association, he favored placing the active work in the hands of the technical telephone men and the practical business men, who were now the ones to work out the problems connected with the independent telephone business and place it on a stable footing, which would put independent telephone investments upon a high plane.

Hon. Hugh Dougherty, of Bluffton, Ind., presented the final report of the committee on patent litigation. He reviewed the work of the committee since the organization of the association at Chicago in June, 1897. The defence of patent suits was taken up by the association at its convention in Detroit in 1898. For legal reasons it has been necessary to keep absolutely secret the names of contributors to the patent litigation fund. It was necessary to do this because they had been advised by high legal authority that in case of a decision adverse to the independent interests, all the contributors to the litigation fund for independent companies would be involved, as parties to the suit if their identity were known, and an injunction against all the parties to the suit could be made at one stroke, where otherwise each company would have to be sued individually. The necessity of keeping contributions secret placed the committee on patent litigation in a somewhat trying position, as they were obliged to solicit funds from independent companies all over the country without rendering to these companies a public account of what they had received. Nevertheless, it was gratifying to note that the confidence was such that the contributions necessary had been kept up until the fight had been completely won. Mr. Dougherty had words of warm praise for the efforts of Judge Thomas, in behalf of the association, and urged that the association provide for Judge Thomas more adequate compensation than he had ever received for the invaluable services that he had rendered it. The total contributions to the litigation fund for the six years had been $50,127; the present balance in the treasury is $162.

Prof. J. C. Kelsey, professor of telephony at Purdue University, read a paper on "The Telephone and the Technical School." He said the first demand for a course in telephone engineering had come from the commercial world rather than from college authorities, and, in fact, the college authorities had been somewhat adverse to the move at first. Perhaps the latter was not strange, since instruction in telephone engineering in times past had been so meager that it was difficult for those not acquainted with the subject to appreciate the necessity for a complete course, where heretofore almost nothing had been taught. As an illustration of how little is done to disseminate information in telephone engineering, it was stated that the Transactions of the American Institute of Electrical Engineers, into which usually all that was best in electrical engineering sooner or later found its way, gave very meager information along telephone lines, the papers and discussions which had been presented so far either being evasions of the subject or degenerating into discussions of rates and in general lacked the thoroughness which characterized the discussion of other subjects discussed before that body. He then reviewed briefly the subjects and methods included in the telephone engineering course at Purdue University.

In the absence of Mr. T. C. Martin, who was unable to be present, to present the matter of census data on the independent telephone industry in person, Judge Thomas outlined briefly the facts that the Census Bureau of the United States Government in attempting to compile these statistics, was doing something which would greatly benefit the independent telephone business, if the requests it made were fully and freely complied with as regards giving information from independent telephone companies. With full authoritative figures regarding the extent of the independent telephone business in the United States, it would be much easier to float independent telephone securities, he thought.

Secretary J. B. Ware spoke along the same line, and said that we would be agreeably surprised at the extent of the business if authentic statistics were available. He urged independent telephone men to comply more carefully with requests for information as to the business in their respective localities, when such requests came from the secretaries of the various telephone associations. The extent of the independent telephone business was usually much greater than could be roughly estimated.

After hearing a communication from President Francis of the Louisiana Purchase Exposition and a brief address by Prof. W. E. Goldsborough, the chief of the electrical exhibit department of that exposition, it was decided to hold the next annual convention at St. Louis, some time during the second week in September, 1904.

At the Thursday morning session, Mr C. E. Tarte, of Grand Rapids, read a paper on "The Economy of Good Construction," in which he pointed out that while most telephone companies were now doing good construction work, an inspection of the work of some companies gave the impression that the companies had been asleep for several years. It is better to do a certain amount of work well he said, than to do twice as much in a way that will necessitate its being done over again in two or three years. As a concrete example of the difference in the cost of maintenance between good construction and poor construction, he took the case of the Citizens' Telephone Company, of Grand Rapids. This company's exchange was completed in July, 1896, and but little cable was strung, most of the lines being on poles carrying eight, nine and ten crossarms, poorly guyed and braced and with common-return wire circuits. Inside the buildings cotton-covered wire was used, both wires were put under one staple, and there were almost no protective devices. After being in service a short time, the wires on the pole line began to get slack because of the overloading of the poles, and with such an enormous number of wires on a pole, it has often required half a day to locate one cross. Chaos existed after every severe storm. Crosses were then so numerous on some of the main lines that no attempt was made to locate any individual cross after a storm, but the repair man simply went to work clearing every cross he came to on a certain pole line, and individual complaints were looked after later. After a storm every available employee was pressed into the service of clearing the lines.

Then the company began a general overhauling of its pole lines. Fewer wires were put on the main pole lines and more cables were used. Wires were kept out of the trees and roof fixtures taken down. The change was not made all at once, but gradually. As to the practical results, it was stated that in 1899, before the overhauling began, there were three line troubles per year per subscriber. In 1900 these had been reduced to 2½ per year, in 1901 to 1½ per year, and in 1902 to one every eleven months per subscriber. In 1903, the records so far indicate that the line troubles will amount to only one trouble per year for every two subscribers. The difference in the cost of line maintenance per subscriber in 1903, as compared with 1899, was $2.63. The total depreciation was only one-third what it was formerly. The company now maintains its lines with fewer men than it had three years ago when there was but one-half the circuit mileage. In conclusion, he said that it was the company that gave the best service at the most reasonable rates that would get the business.

At the conclusion of the paper, President Thomas spoke of Mr. Fisher's unique policy in Grand Rapids, in placing all the telephone company's securities among local investors in the immediate vicinity, the company having no bond issue and depending entirely on money raised by the sale of stock in and near Grand Rapids.

F. A. Demarest, general superintendent of the Interstate Telephone and Telegraph Company of New Jersey, read a paper on "Eastern Telephone Development." He said that few realized the amount of independent telephone development that had been going on in the East. He reviewed the difficulty at first in securing capital for these enterprises in the East, the difficulty of securing franchises and the trouble of securing good telephone apparatus. The first exchanges of independent companies were as to size on estimates of the amount of business in sight, these estimates usually being made by taking the Bell's list of subscribers as criterions. He gave several examples, showing how the independent exchanges have been swamped with business, and said that these examples could be multiplied indefinitely. He then proceeded into a detailed account and enumeration of the various more prominent eastern telephone companies. This formed the remainder of his paper.

L. W. Stanton, consulting engineer, of Cleveland, then gave a brief talk on economy in telephone service. The first part of his talk went to show how erroneous it is to assign a certain fixed number of lines to each operator in exchange, without considering the character of these lines. The number of lines in front of an operator is no indication whether that operator has more or less than she can properly manage, because of the varying number of calls of the different classes of lines. This is something not always considered in laying out or in operating an exchange. For measured service 1200 calls per day per operators' position had been found to be about the limit of efficient work. For ordinary unlimited service 1800 calls per day per operator's position was about the proper limit. The day's work in this case included all the calls answered by the various shifts of operators during the twenty-four hours. In connection with counts made as to the number of calls answered per day per operator, some provisions were advisable to prevent operators from recording more than the actual number of calls in order to run up their individual records. He cited examples of exchanges where by a study of the volume of traffic on different sections of the board, and a proper distribution of work among the operators, a great saving in the expense of operators' service was effected. On one exchange he knew of, it was costing 57 cents per month per subscriber for operators' wages, while in another exchange of the same size, operating under almost identically the same conditions, the expense was only 19 cents per month per subscriber; furthermore the service was better in the latter exchange, as the average time of response to calls was 2⅓ seconds in the latter, while it was over 5 seconds in the former. Some exchanges were operated as low as 13 cents per month per subscriber for operators' wages.

He warned companies to beware of idle investment in cables, due to the non-use of a number of pairs of wires in each cable. The mistake has been made among independent exchanges of terminating a given number of pairs at one cable box, the same number at the next cable box and so on, giving each pair of wires only one outlet. Supposing that twenty-five pairs were brought up at each cable box, it was frequently the case that only fifteen pairs for example, would be called for at one box, while at the next box forty might be needed. In order to provide for the forty, more investment would be made in new cable. In this way many companies had paid out uselessly a great deal of money for cables. This could all be overcome by having multiple terminals for a number of the pairs of wires in each cable, so that a subscriber could be connected to a certain pair of wires at any one of several neighboring boxes. Furthermore, multiple terminals of this kind would facilitate party line service. At this point he brought up the matter of party lines. It had been argued that if a subscriber could not afford to pay for an individual circuit, he ought not to have a telephone at all.

Mr. Stanton's reply to this was that there were a great many whose business would not warrant the expense of an individual line, and that if they could not get party-line service, they would not have a telephone at all, even though they might have limited need for it. Party-line service, in order to be profitable, at the low rates which it commanded, must be operated from the main pair of wires. Some independent exchanges which had begun to install party lines, as the result of an afterthought, and had not planned for them in the first place, had run a separate pair of wires for each subscriber clear to the switchboard, so that they were party lines only so far as the switchboard was concerned, thus practically doing away with any economy over individual lines in maintaining party line service, as far as the cost of operation and maintenance of the lines are concerned. The matter of party lines must be considered by independent exchanges.

Mr. George Holmes, of Sherman, Texas, introduced a resolution declaring it to be the sense of the association that since the Kellogg Switchboard & Supply Company had passed under the control of men prominently identified with the Bell interests, no member should purchase apparatus of that company. The resolution expressed disapproval of the transaction in varied and forcible language. This resolution was tabled indefinitely, without discussion.

At this juncture, Mr. J. G. Ihmsen, of Chicago, obtained the floor and said that he had a very pleasant duty to perform. As had been intimated before in the convention, there was a strong feeling that this convention would not be allowed to adjourn without some tangible expression of the appreciation felt for the efforts of Judge Thomas as president during the past six years. In behalf of the Chicago friends of Judge Thomas, Mr. Ihmsen presented him with a magnificent gold watch, suitably inscribed. Judge Thomas in accepting the watch expressed his deep gratitude and appreciation of the feeling which prompted the gift. He referred to criticisms of the policy of the management of the Association in the past as something now to be buried and forgotten. He believed that with the report made at this convention the management had been entirely vindicated in the showing that had been made at the end.

Mr. H. D. Critchfield said that as individuals and companies grow in strength and power, they are sometimes forgetful of how inter-dependent they are. He hoped that now that the independent telephone companies of the country had become powerful, that they would not lose sight of the fact that they must still stand together. He then nominated Mr. Hugh Dougherty, of Bluffton, Indiana, for president of the association; the nomination was indorsed by over a hundred independent telephone manufacturing and operating men, and Mr. Dougherty was unanimously elected president. The other officers chosen were as follows: Vice-president, Senator C. W. Kline, of Hazelton, Pa.; secretary and treasurer, Frank G. Jones, of Chicago; Executive Committee, Prof. W. E. Goldsborough, of Purdue University, Lafayette, Ind.; H. D. Critchfield and J. G. Ihmsen, of Chicago; Thomas W. Finucane, of Rochester, N. Y.; W. E. Doolittle, of Lafayette, Ind.; C. E. Tarte, of Grand Rapids, Mich.; A. L. Tetu, of Louisville, Ky.; E. E. Clement, of Washington, D. C., and Captain E. H. Moulton, together with the president and secretary.

Secretary-elect Jones being called to the platform, said that he believed that the present meeting marked the beginning of a new and greater era for the association. Mr. Critchfield closed the convention with a few appropriate remarks regarding the doubts which had been expressed in some quarters in the past as to the management of the association and the criticisms which came originally from those who had contributed nothing to the association. All the doubts of the past having been dissipated, he thought it due to the officials who were retiring to give them a hearty vote of thanks. The motion was enthusiastically carried, and the convention adjourned.

SOME RECENT ELECTRICAL PATENTS

Laminated-Lever Knife Switch.—The difficulty of building switches of the knife-blade variety for carrying very heavy currents, as is well known, lies in the fact that when the contact jaws are made sufficiently heavy to carry the current they have no flexibility; consequently, the work of opening and closing such a switch is by no means inconsiderable. Various methods of reducing this disadvantage have been applied, such as slitting the jaws so as to divide what would ordinarily be a single jaw into several individual pieces of metal arranged edge to edge; dividing each blade of the switch into several parallel strips and similarly dividing up the contact jaws; mounting the jaws either flexibly or movably and re-enforcing them with springs, etc. One of the most recent methods of reducing the friction in large switches is illustrated by Figs. 1 and 2 herewith, which are reproduced from a patent issued to E. N. Hewlett and C. C. Badau, of the General Electric Company. The desired flexibility is obtained by laminating the movable portions of the switch, and in order to avoid the difficulty of pivoting a laminated blade, the laminations are bolted to a solid blade *F*. The stationary contacts are of the jaw type and the solid blades, *F*, of the switch are fitted accurately but not tightly to the slots between the jaws, while the laminated brushes make the actual current-carrying contacts on the outsides of the jaws. The switch embodies the additional feature of a supplementary brake, consisting of flexible terminals *E*, which make contact with a shoe integral with the solid switch lever before the laminated contacts touch the jaws. Upon opening the switch, therefore, the circuit is broken at the supplementary contacts instead of the laminated brushes. The supplementary contacts presumably would be faced with carbon, since they have to take the arc. Patent 728,231.

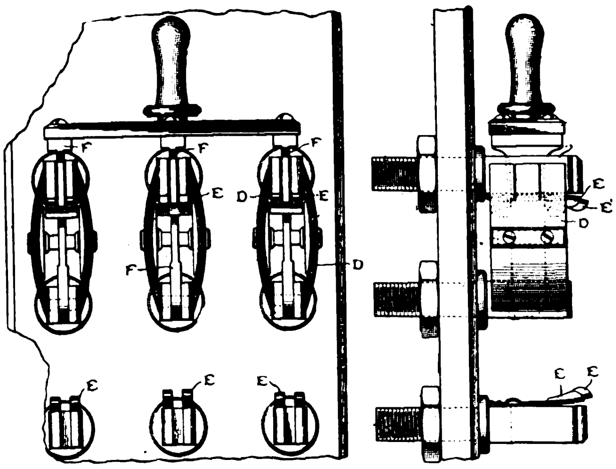

FIG. 1.—LAMINATED LEVER KNIFE SWITCH.—FIG. 2.

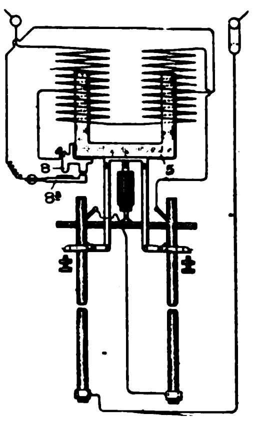

FIG. 3.—MULTIPLE ARC LAMP.

Multiple Arc Lamp.—The idea of constructing a single arc lamp with two or more sets of carbons to be operated simultaneously developed many years ago, and several attempts have been made to build such a lamp. These have hitherto failed uniformly, the chief obstacle being the difficulty in persuading the various pairs of carbons to burn with the same degree of rapidity so that the simultaneous feeding of all of them would produce satisfactory results. With a view to eliminating this difficulty in the regulating mechanism, W. C. Fish has devised and patented the arrangement indicated in Fig. 3 herewith. The lamp is intended for operation upon a constant-potential circuit and the regulating magnet is therefore series wound. The armature or double plunger 5 carries clutches for both pairs of carbons so that the two are fed simultaneously. At certain intervals, however, the frequency of which may be regulated by adjusting the contacts, 8 and 8*a*, the plunger reaches a point where the last mentioned contacts come together and weaken the solenoid coils by cutting out a section of them. This releases the plunger entirely, allowing both pairs of carbons to come together, when the rush of current enables the solenoid to pick them up again and start both the arcs afresh. Thus, no matter how unequally the two arcs may burn, they are restarted at reasonable intervals with the carbons exactly the same distance apart every time. The patent also describes other methods of periodically weakening the solenoid coils, such as shunting them by means of a resistance. Patent 729,315.

NOTES.

The New York State Independent Telephone Association held a meeting on June 10, at Utica, N. Y. The meeting was called to order by President George R. Fuller, of Rochester, N. Y., who discussed the conditions under which the meeting was held and named the various points in the State at which Independent exchanges had been established. With regard to membership in the Association, he proposed certain changes based on $2 for the first 100 telephones and $1 for each additional 100 telephones up to 500. From 500 up to 1000, 50 cents for each additional 100. Above 1000, 25 cents for each 100, extra assessments for any one year being limited to 25 per cent of the annual dues. He also proposed liberal treatment of the supply trade.

Mr. C. O. Harris read a paper on the "Growth of Independent Telephony in the State of New York," and Mr. Potter, of Syracuse, read a paper on "Uniformity in Telephone Service."

Officers for the ensuing year were elected as follows: President, George R. Fuller, of Rochester; first vice-president, Howard Hendrickson, of Albany; second vice-president, J. H. Scofield, of New York City; secretary and treasurer, J. B. Ware, of Buffalo. Executive Committee: H. H. Persons, of Buffalo; B. G. Hubbell, of Buffalo; S. B. Rawson, of Niagara Falls; Edward Davis, of Binghamton; T. H. Ferris, of Utica; J. S. G. Edwards, of Gloversville; J. S. Brailey, Jr., of Herkimer, and T. S. Lane, of Jamestown. Inspectors: C. H. Poole, of Utica, and C. O. Harris, of Rochester.

Standard Business Literature.—The project of getting manufacturers to adopt standard sizes for catalogues, folders, cards and other trade literature is being vigorously pushed by Mr. F. G. Bolles, chairman of the Ohio State Committee of the Standardization of Literature, and the plan is well worth adoption. It is entirely unnecessary to point out the advantages that would accrue from having such literature restricted to a few uniform sizes; these become apparent upon giving the subject the least bit of thought. The standard sizes advocated by the committee are as follows:

Card index cards, 3 x 5 inches;
Flyers or folders, 3½ x 6 inches and 4 x 6 inches.
Catalogues, 6 x 9 inches and 9 x 12 inches.
Letter paper, 8½ x 11 inches.

The need for two widths of flyer or folder is not apparent, and the two sizes specified are so nearly the same that the larger size might reasonably be expected to meet all requirements. It might be found advantageous also to add to the above list a standard size for order blanks.

A. S. M. E. Convention.—The forty-seventh meeting of the American Society of Mechanical Engineers was held at Saratoga, N. Y., June 23 to 28, and was one of the most successful of the society's conventions. The papers read were as follows: "Tests of a Twelve Horse-power Gas Engine," by Prof. C. H. Robertson; "Bursting of Emery Wheels," by C. H. Benjamin; "The Hot Well as an Oil Extractor," A. H. Eldredge; "Tests of a Hydraulic Elevator System," by R. P. Bolton; "Fits and Fitting," by Stanley H. Moore; "Positive Governor Drives for Corliss Engines," by A. H. Eldredge; "A Turbine Flow Recorder," by C. M. Allen; "Shop Management," by Fred. W. Taylor; "The Mechanics of Air-brake Systems," by H. G. Manning; "The Steam Turbine from an Operating Standpoint," by F. A. Waldron; "An Indicating Anglemeter," by C. E. Sargent; "Alternating-current Motors for Variable Speed," by W. I. Schlichter; "A Method of Testing Gas Engines," by E. C. Oliver; "A Rational Train Resistance Formula," by John B. Blood; "Drawing Office Equipment," by John McGeorge; "Strains Produced by Excessive Tightening of Nuts," by A. Bement; "Some Data on Hoisting Hooks," by John L. Bacon; "Water and Heat Consumption of a Compound Engine at Various Powers," by D. S. Jacobus; "A Comparative Oil Test," by William F. Parrish, Jr.; "Experiment Boiler of Ohio State University," by E. A. Hitchcock; "A Graphical Daily Balance in Manufacture," by H. L. Gantt. On account of the fact that the convention was held just as this issue of the American Electrician was being sent to press, it is impracticable to present a detailed report of the proceedings. Abstracts of such papers as come properly within the scope of this journal will be published later.

Canadian Electrical Association.—The thirteenth annual convention of the Canadian Electrical Association was held in Toronto on Wednesday, Thursday and Friday, June 10, 11 and 12. The attendance was one of the largest in the history of the association, and the interest taken in the discussion of the various papers brought before the convention promises well for the future of the association. Aldermen Starr and Ward, on behalf of the city, extended a hearty welcome to the delegates and their friends, which was ably responded to by Mr. A. A. Dion, of Ottawa.

Mr. B. F. Reesor, manager of the Electric Light and Power Company, Lindsay, Ont., occupied the chair, and at the opening of the convention delivered the president's annual address, in the course of which he announced that a new feature, at least to this association, had been inaugurated this year, namely, the establishing of a "Question Box," and following along the lines of the National Electric Association he suggested that a question box editor should be elected, whose duty it would be to look after questions pertinent to the interests of light and power companies and electricity generally. The "Question Box" was conducted by Messrs. Hunt and Dion and proved a valuable source of information to the members.

On Wednesday afternoon a paper on the training of the high tension engineer, prepared by Mr. Paul Lincoln, of Pittsburg, was read by Mr. Charles F. Scott, chief electrician of the Westinghouse Electric & Manufacturing Company. The paper pointed out that there were two schools in which the electrical engineer could receive his training, but only one in which he must receive a course before he could be called a high-tension engineer. Those things which were learned in the schools must be supplemented by the things which could only be learned by experience. In the ensuing discussion Mr. Black spoke with regard to the operating end of a transmission plant; he said he had been very much struck with a remark to the effect that when things were designed and everything planned out so that you would naturally expect apparatus to work perfectly, it did not always work that way. He thought that had been the experience of almost everybody who had had to do with operating electrical machinery.

On Thursday morning a valuable paper was read by Mr. R. T. Lozier, on "Variable Speed Motors and Their Relation to New Shop Methods," which was amplified by Mr. Lozier and afterwards discussed very fully by Messrs Gossler, Higman, Hynes, Leonard and others. In the afternoon of the same day two papers were read, one by Mr. G. U. G. Holman, of Quebec, on "Some Points Relating to Submarine Electric Power Cables," and another by Mr. J. W. Farley, entitled "High-Tension Transformers." In answer to questions on his paper, Mr. Holman stated that he thought it was advisable to use lead with a rubber-covered cable, inasmuch as it was an extra precaution which his experience had shown was not worth paying for. In answer to a question as to the cable *versus* aerial lines, he said that if the conditions were favorable, the aerial line was by all means preferable. A paper was read by Mr. R. J. Russell, of St. Louis, Mo., on "Single Phase Motors as a Means of Increasing Station Earnings."

In connection with the Question Box some of the questions asked and answers given were as follows: Question: Is it advisable to "ground" secondaries at the transformer or in the building supplied? Answers: (1) At the transformer. (2) To ground secondaries at the transformer would seem to be the more preferable method. It would ensure all consumers' lines being protected; whereas grounding in the building would often be found inconvenient and too often would be neglected altogether.

Question: Should meters be tested in place or should they be returned to the station for that purpose? Answers: (1) In some cases in place, in others taken to the station. (2) Government regulations require that meters should be presented to the inspector for inspection. To test *in situ* is extremely inconvenient and sometimes impossible. An extra fee is charged for meters so tested.

Question: What has been the experience of water power plants with the maximum demand flat rate, controlled by a Lacey controller, or similar device? Answers: (1) Systematic inspection, while not having been shown to be absolutely necessary so far, would seem to us to be very advisable and a convenient method of testing controllers in places desirable. (2) An experience of about six months with the Lacey controller would indicate that it furnishes the best means so far put on the market to deal with flat rates. Common sense would dictate that this instrument, the same as any other device for measuring current, should not be allowed to go for an indefinite time without being carefully inspected and tested. (3) The maximum demand rate by a Lacey controller suits a large class of customers, since the customer knows the amount payable each month regardless of the hours of burning. The contractor has the benefit of the load to put on a transformer; no meter readings and fewer inspections.

On Friday morning officers and committees were elected for the ensuing year as follows: Mr. J. J. Wright (Toronto), president; J. B. Thornton (Montreal), first vice-president; A. A. Wright, M. P. (Renfrew), second vice-president; C. H. Mortimer (Toronto), secretary-treasurer. Executive Committee: Messrs. John Yule, A. B. Smith, P. G. Gossler, A. A. Dion, Gordon Henderson, B. F. Reesor, C. K. Greene, C. B. Hunt, J. A. Kammerer and H. O. Fiske. Committee on Statistics: Messrs. A .A. Wright, D. R. Street and J. W. Purcell. Committee to confer with Underwriters: Messrs. P. G. Gossler, A. A. Dion, J. J. Wright, G. U. G. Holman and Mr. Wight. Committee on Legislation (Ontario): Messrs. Hunt, A. A. Wright, Reesor, Dion, Breithaupt, McCulloch, J. J. Wright and J. W. Purcell, with power to add to their numbers; (Quebec): Messrs. E. A. Evans, J. McCarthy, P. G. Gossler, Sangster and Holman, with power to add to their numbers.

The convention will be held at Hamilton, Ont., next year.

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

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CONTENTS.

Lighting and Power Plant of Landers, Frary & Clark, by W. G. Viall 329
The Heyland Induction Motor, by A. S. McAllister 331
Electrical Display Signs, by George Rice.... 334
Telephone Engineering, by F. J. Dommerque 335
Relative Advantages of Electrical and Mechanical Methods of Variable Speed Control for General Power Service, by William Cooper 337
Convention of the National Electric Light Association 341
Boiler and Furnace Efficiencies, by A. Bement 351
Abstracts from Foreign Contemporaries..... 355
Convention of the Independent Telephone Association 358
Some Recent Electrical Patents 360
Notes 360
Editorial 362
A Convenient Repair Shop Floor Crane, by Francis H. Doane 364
Electric Train Safety Device, by E. C. Parham 365
Monocyclic Current from Three-Phase System, by F. Hardie Jeannin.......... 366
Intercommunicating Telephone Systems, by A. Dallam O'Brien 367
Tests of Motors Driving Machine Tools, by Miles F. Moore 369
The Application of 4-ampere Series Alternating Enclosed Arc Lamps to City Lighting, by J. Henry Hallberg 369
Relation between Effective and Mean Values of Currents or Electromotive Forces, by J. J. Cort 370
Notes on Railway Feeder Problems, by Wm. A. Del Mar 371
Lessons in Practical Electricity 373
Letters on Practical Subjects 375
Queries and Answers 377
Telephone Equipment of the Manhattan Elevated Railway 378
The New Allis-Chalmers Gas Engine 379
Cast Grid Rheostats 380
New Apparatus and Appliances 381
New Books 384
Allis-Chalmers Annual Report 384
National Electric Light Convention Notes .. 384
Independent Telephone Convention Notes .. 386
Obituary 386
Personal ....Adv. 55
Trade Publications ....Adv. 55
Business News ....Adv. 55

The Heyland Induction Motor.

The very lucid contribution on this subject which will be found in another column can scarcely fail to interest everyone who is concerned with motor operation and has not already investigated this peculiar machine; what may have previously seemed to the uninitiated a hopelessly complex subject has been simplified to a remarkable degree by Mr. McAllister's treatment. The "meat" of the Heyland invention is the provision of an exciting current in the rotor winding, which takes the place of the usual primary exciting current. This current is superposed upon or combined with the current that is induced in the rotor windings by the action of the field flux upon the conductors in the ordinary manner, and its lagging component is extremely small in comparison with that of the ordinary exciting current in a stator winding, because of the relatively low secondary frequency and the unidirectional wave form of the current; consequently, the power factor is inherently higher than in the ordinary case. And since the reaction of the exciting current (which is made unidirectional by the commutator) upon the work currents in the stator windings is similar to the reaction between the field and armature of a synchronous motor, over-excitation by the commutated secondary current advances the phase of the primary currents with respect to their e.m.fs., and by this means it becomes possible to raise the motor's power factor to unity.

The compensated motor thus appears to be a mixture of the ordinary synchronous and induction machines. The reactions between the stator and the alternating current induced in the rotor are those of the induction motor, while the relation between the stator and the commutated exciting current in the rotor is substantially identical with that between the armature and field of a synchronous motor. To the beginner the operation may seem to be similar to "lifting oneself by one's boot straps," the rotor winding being made to provide a field and then pull itself around by reacting on that field. It must not be forgotten, however, that the current which excites the field does none of the "pulling"; that is all done by the current induced in the rotor windings by the primary work current in the stator windings.

As is well known, one of the chief drawbacks of the induction motor is eliminated in this machine by reason of the feasibility of raising its power factor to unity, and in view of the wide influence of the power factor outside of the motor itself, it would appear that this improvement would much more than offset the entailed complexity of the commutator and brushes. Mr. McAllister expresses the opinion that the increased output made possible to a given size of frame will prove the chief incentive to the adoption of this type of motor. It appears to us, however, that the increased output capacity and the improvement in regulation of a given generating and transformer equipment resulting from the elimination of the fractional power factor are far more important than the increase in the output of a given motor frame; the latter can affect only the manufacturer, or the purchaser of the motor, while the former affect the service throughout a station plant. As to the price paid for the improved power factor in the sacrifice of some of the simplicity of the induction motor, it is scarcely necessary to point out that the compensated machine is still simpler than the ordinary direct-current motor, and that the latter, when properly designed and built, stands any amount of hard service and requires a ridiculously small amount of attention.

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Variable Speed for Power Service.

Superintendents of manufacturing establishments to whose notice Mr. Cooper's paper on variable speed control may come will doubtless find much of value to them in the paper, and certainly many statements of interest. The paper is printed almost in full in another part of this issue, and is unusually free from the violent partisanship and arbitrary *dicta* which so frequently characterize discussions of this general class. To the contrary, both mechanical and electrical methods are treated impartially, the advantages and disadvantages of both systems, as the author sees them, being pointed out. One of the glaring defects of the cone-pulley method of obtaining several speeds, mentioned by Mr. Cooper, is a perfectly obvious fault, but one that nevertheless appears to receive scant consideration if any. This is the fact that the speed gradations are made in steps of from 50 to 100 per cent. Fancy a variable speed motor for machine tool service that could not be graded more closely than 50 per cent at each step. Another point against mechanical speed control as compared with the variable-speed motor is that the very best mechanical speed-changer requires a considerable expenditure of muscular effort for its operation, and usually necessitates a change in the position of the operator. This, of course, means a very appreciable loss of time, and in many cases results in work being carried on at a disadvantageous speed because it is "too much trouble to shift the belt" or whatever needs to be shifted.

A point in motor construction that has not been universally recognized is that for multivoltage speed control the armature circuit should have a lower resistance than for single voltage operation, for the reason that when working on low voltages the variation in speed between no load and full load becomes excessive with the ordinary armature resistance. Thus, if a 240-volt motor when operating at full voltage shows a speed variation of 4 per cent between no load and full load, due to armature resistance, the variation when operating at 40 volts will be approximately 24 per cent. Obviously, therefore, in order to avoid such results without seriously sacrificing economy of construction, motors for multivoltage operation should have as few armature coils, or turns per coil, or both, as possible, with extremely high magnetic densities at maximum excitation. Incidentally, it might be mentioned that this general policy in motor construction produces the best results in any class of service, and particularly in heavy-duty work.

Mixed Loads on Three-Phase Generators.

The best method of supplying lighting and power loads simultaneously from a common three-phase source, like many other "best methods," is yet to be determined, and will probably remain so through all time, except as to a few limited and well-defined sets of conditions. However, the replies to an inquiry on this point which formed a part of the "Question Box" at the last electric light convention were remarkably uniform in recommending the supply of the lighting load from all three "phases," where this forms a large proportion of the total load, and this would appear to be the logical method, generally speaking. But generalizations are not always valuable as applied to complex problems of this character involving a number of widely varying factor, all of which vitally affect the solution; and there are many cases of satisfactory operation where the lighting load is all supplied from one "phase," that one "phase" being regulated carefully while the other two are not so closely controlled.

The solution of the problem under discussion obviously lies hypothetically in the direction of a phasing transformer capable of changing three phases into one without unusual energy losses or curtailment of output. Unfortunately, the resultant of three equal e.m.f.s., currents or magnetic fluxes differing in phase by 120° from each other is zero, and if one of the three phases be reversed so as to make the phase difference 60° most of the time, the sum of the three will be only twice the value of one of them. Thus, a three-legged transformer core with three primary and three secondary windings could be supplied with three-phase currents and be connected to deliver a single-phase current, but the secondary e.m.f. would be only about double the e.m.f. of any one of the three secondary coils, one-third of the total possible power being "tied up," so to speak, by the opposition of internal e.m.f.s. Moreover, the secondary current could not, of course, be practically half a cycle behind the primary current in each coil, as would be the case with independent secondaries, and the regulation would be atrocious—in short, such an arrangement would be utterly impractical; otherwise, it would have been adopted long ago. The same is true of an arrangement that has been suggested by a correspondent—a single core within three primary windings and a single secondary, the magnetic flux thus being the resultant of three excitations tending to set up independent fluxes of different phases.

Obviously, the ideal solution, so far as regulation alone is concerned, is obtainable by the use of rotary phase-changers operated at the station and delivering single-phase current to lighting feeders. The practical objections to this plan, however, are as obvious as its solitary advantage, and far weightier. It would seem that the time is about ripe for two-phase or three-phase lamps, several types of which have already been patented in this country. Two-phase incandescent, Nernst and arc lamps would have no disadvantages that could not be eradicated by the application of a little sound engineering sense, and the adoption of such devices would settle once for all the question of unbalanced circuits. Meanwhile, the expedient of connecting lamps in pairs might be found unobjectionable in many cases of commercial lighting. The two lamps of each pair could be connected on different phases of a two-phase distribution system, the familiar three-to-two-phase transformation being employed, and the control switches could readily be arranged to make it impossible to put one lamp alone into service. Of course, the practical disadvantages of this arrangement would in many cases outweigh the advantage of balanced circuits, and it could scarcely be called practical at all for residence lighting.

Parallel Operation of Steam and Water Driven Dynamos.

One of the "Question Box" inquiries at the recent electric light convention, concerning paralleling alternators, brought out a reply that recalls a very pretty example of parallel operation that came within our observation many years ago when the practicability of paralleling was just beginning to receive serious attention. This consisted, briefly, of working in parallel two single-phase alternators, one of which was driven by a steam engine in one station while the other was driven by a turbine water-wheel at a station not quite a mile distant. The operation was flawless after the machines were once got together, the water-wheel being worked with no governor except an emergency stop of the fly-ball class arranged to close a gate if the speed should become excessive; but getting the machines connected in parallel was in those days an appalling job. Such an arrangement is one of the few that work out as beautifully in practice as they appear on paper. It proved a perfectly simple matter so to adjust the engine governor that the water-wheel could be given full gate and worked at full load while the engine governed for variations in the load, so long as the total load was considerably beyond the ability of the water-wheel.

The paralleling of two stations is, of course, a matter of common practice now where there are two or more stations, as in Brooklyn and Boston, for example. But the particular class of parallel operation just mentioned is not so very common because the requisite conditions are not frequently found justifiable. Obviously, the plan is applicable to plants containing both steam and hydraulic prime movers in a single station, and no doubt it has been thus applied in numerous instances. It is rather easier to carry out, of course, where direct-current generators are used, and is even a prettier operation under such conditions than with alternators, since the regulation and apportionment of the load approach more nearly to absolute automatism. The present writer has known of a few cases where this principle was applied with entire success to constant-current dynamos, operated, of course, in series.

A CONVENIENT REPAIR SHOP FLOOR CRANE

BY FRANCIS H. DOANE.

Undoubtedly one of the reasons for the success of American shop methods is the practice of installing labor-saving devices for facilitating not only the manufacture but the handling of material. A person provided with a properly mounted tackle can perform the work of assembling or taking down machinery that would otherwise require the efforts of several men. A brief description is herewith given of a simple form of floor crane which has been in use a number of years and has proved to be of value for many kinds of work.

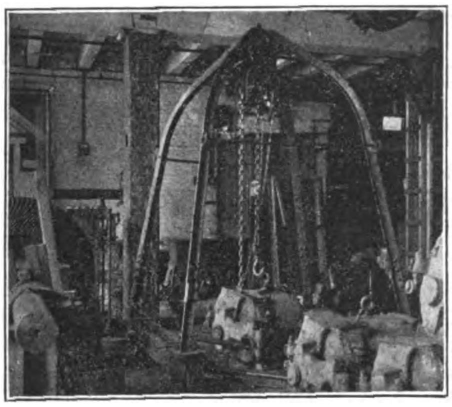


FIG. 1.—REPAIR SHOP CRANE.

The crane was designed for use in a large electrical repair shop. Its general plan was made and the detailed design furnished by a large blacksmith company. The nature of the work for which it was principally used was the dismantling and assembling of dynamos and motors and for use in shipping work. A general view of the crane is given by Fig. 1. It is 8 feet high, 6 feet long, and has an inside span of 5 feet. The wheel trucks are made of 6-in. channel irons having a 2-in. flange. The manner of building the truck and mounting the wheels is illustrated in Figs. 2 and 3. Spacing plates, *E*, are placed on each end of the truck, as shown in Fig. 3. These serve as a base for the T-iron upright, *C*. Spacing plates, *F*, are also fastened to the bottom flanges of the channel irons, the irons being held 3 inches apart. The T-irons, *C*, are secured to the spacing plates, *E*, by means of small angle irons, *B*. The journals for the wheels, *D*, are bolted to the lower flanges. On one end of each truck a shaft, *A*, is provided; this is bolted to the outside channel and forms a support for a wheel lever.

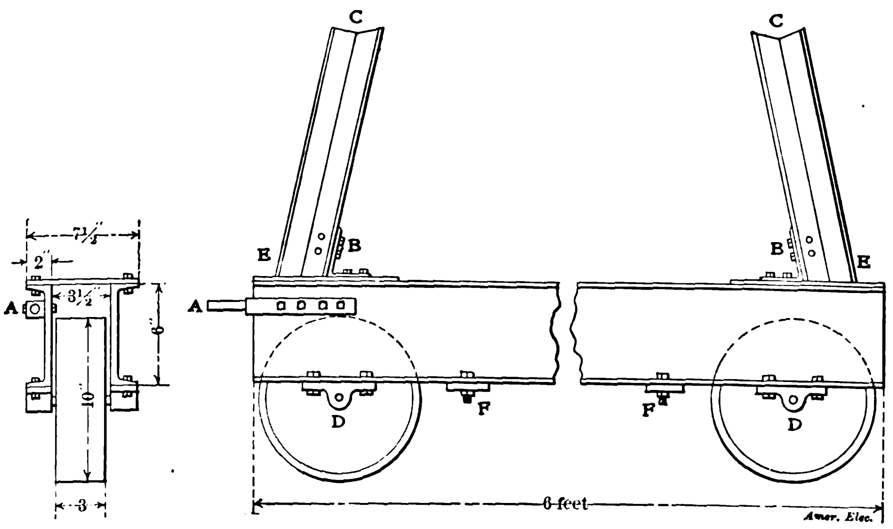
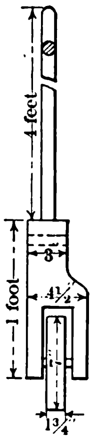


FIG. 2.—FRONT AND SIDE ELEVATIONS OF CRANE TRUCK.—FIG. 3.

The frame of the crane is made of 3-in. x 3-in. T-iron. The lower end of each of the four legs rests on a spacing plate on the trucks and the upper ends are joined by a heavy casting which supports an eye bolt for a 2-ton chain fall. Tie rods are provided, as shown in Fig. 1, to strengthen the frame.



In moving the crane about, when there is no load on the chain falls, and the room for moving the crane is limited, a bar may be used to pry over one end of the crane, so that it will point in the direction of the desired motion. If, however, there is a heavy load on the falls, this is not an easy operation. To obviate this difficulty, two wheel levers of the form shown by Fig. 4, are provided. The lower part of the lever is a casting supporting the wheel, *W*, and the handle is an iron rod 4 feet long. A hole, *G*, is provided large enough to take the shaft, *A*, shown in Fig. 3. These two wheel levers are mounted on one end of the crane, one on each wheel truck. With the handle in the normal position, *S*, Fig. 5, no weight is placed on the lever wheels, the weight being on the four truck wheels. When it is necessary to alter the direction of the crane, the lever handles are forced over to the position *R*, Fig. 5, whereby the two truck wheels are lifted from contact with the floor and the weight of the crane is carried on the two truck wheels, *D*, in the rear and the two lever wheels, *W*, in the front. These latter wheels, as will be evident, revolve at right angles to the truck wheels, and under these conditions the crane can be quite easily forced around to any desired position. When this position is attained, the lever wheels are pushed back to their normal position and the weight of the crane is again taken by the four truck wheels, when the crane can be moved forward or backward in the new direction. A stop and catch should be provided so as to limit the throw of the lever and to hold it securely in position while the crane is being shifted.

In taking down a dynamo, the crane is run over the machine, the top field frame lifted, the crane moved and the field frame placed on the floor. The crane is then moved over the machine again, and the armature is lifted out and placed where desired. The usual manner of doing this work, before the crane was in service, was to sling a chain fall to a beam, lift the field frame and then pull it to one side while lowering on the chain fall. The advantage of the crane method is apparent. Another use of the crane is for stacking up motors. The crane can pick up, for instance, a railway motor and set it on a row of other motors, thus saving floor space. This method of storing motors is illustrated in Fig. 1. Other uses of the crane will suggest themselves. The crane is of comparatively cheap construction and can be built for approximately one hundred dollars.

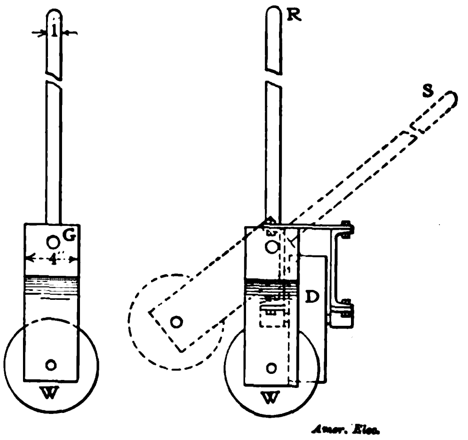


FIG. 4.—WHEEL LEVER.—FIG. 5.

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Underground Wiring for Towns.—The question of placing wires underground in towns depends entirely upon the nature of the town; that is, whether the customers are spread over a comparatively large territory or a congested territory. If they are close together and did not spread very far, the Edison Electric Illuminating Company, of Boston, says the low-tension system would be desirable and the cheapest way to install this would be with the Edison tube system. If customers were spread over a large territory, a cable and conduit system would be very much cheaper, as a system of high-tension distribution could be used in conjunction with this, transformers being placed in manholes and individual customers being supplied from the regular manholes at the corners, so as not to necessitate the introduction of a large number of manholes. W. E. Carlton says that there are few places where it will pay to take a scattered residence load on underground lines, while it is frequently possible and advisable to go under ground in a concentrated business district.—*Question Box.*

ELECTRIC TRAIN SAFETY DEVICE.

BY E. C. PARHAM.

The danger attending the entrusting of the lives of a trainload of passengers to a single man located in an enclosed cab on one end of a train has long been realized. As a partial but tangible recognition of such danger, the electric operating boxes or master switches employed in the operation of modern electric trains are of the "dead man" type; that is, their construction is such that should the motorman, as a result of sickness, accident or design suddenly become helpless, a properly disposed spring automatically returns the operating handle, or its equivalent, to the "off" position, thereby depriving the train of all motive power. As far as the idea embodied in the so-called dead man controller goes, it is all right, because it insures that the motive power shall be automatically interrupted the instant the operator for any reason whatsoever becomes unable to control it; but the idea does not go far enough. Suppose that the motorman should drop dead while the train is descending a grade; automatic interruption of the motive power would not prevent the train's speed from accelerating to a value sufficient to cause the train to telescope the train ahead or to turn turtle at the next curve. Or suppose the motorman to become helpless while the train is ascending a long grade; the motive power would be automatically cut off and the grade assisted by train resistance would, in course of time, bring the train to a stop; but unless the rest of the train crew were made aware of the motorman's condition of helplessness in time to operate the conductor's brake-valve or take equivalent measures to secure a stop, the train would roll backward, perhaps acquiring high speed in that direction, and finally collide with its follower or pitch off at a curve or spring switch. Neither of these possible conditions is calculated to be pleasing to the man or woman of average imaginative powers; and when one stops to consider that in railway work where so many lives are at stake, all possibilities of catastrophe should be recognized and provided for as probabilities of catastrophe, is it any wonder that the daily papers should periodically agitate the question of legislation to compel the elevated railroad companies to have two men on the front end of all trains, to absolutely avert all possibility of a train's ever running wildcat should the operator fall dead or otherwise become helpless to stop it?

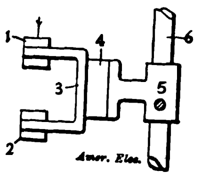

FIG. I.

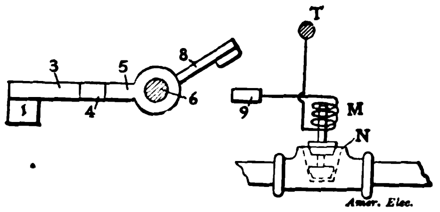

FIG. 2.

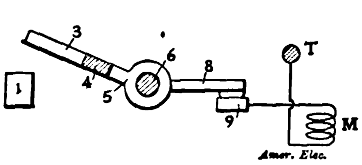

FIG. 3.

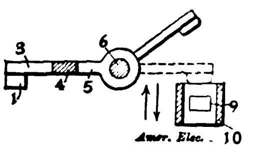

FIG. 4.

What is needed to avoid the direful disaster liable to happen as a result of such a condition, is some automatic device that will not only interrupt the motive power should the motorman for any reason become helpless to control it, but will apply the brake as well the instant the interruption of the motive power is effected. The dead man feature of all master controllers used in the operation of up-to-date trains accomplishes half of the desired condition. The idea at once suggests itself that the other half could be obtained simply by having the master controller handle so provided that when it flies to the off position it might close a local circuit, including an electromagnet designed to open a valve that establishes a connection between the air-brake train line and the atmosphere. This is the fundamental idea of the device to be proposed, but there is one refinement to be introduced, viz., some simple means must be provided whereby the motorman may be at liberty to return his operating handle to the off position under normal conditions of operation and without bringing the emergency brake device into action. This refinement necessarily, as far as we can see, slightly increases the precautions to be taken by the motorman. Some better qualified thinker on such matters will no doubt devise a means of avoiding this apparently undesirable feature; but suppose that it cannot be avoided, what is a little extra precaution on the part of a motorman, and especially when a failure to observe such a precaution will simply result in retarding or stopping the train, compared with the immeasurably greater precaution affected to insure the safe conveyance of hundreds of human beings. Furthermore, such an objection loses weight where trains operate on elevated structures and over private rights of way where the motorman is at liberty to give all of his attention to the operation of his controlling and safety devices.

Some such simple attachment is especially adaptable to the "Type C" master controller of the "Type M" train control system built by the General Electric Company and the one most extensively in use. On this master controller, in order to keep the motor circuits on all cars closed, the motorman must keep pressed down a button in the knob of the handle of the operating master controller. If for any reason he relaxes pressure on this button, an auxiliary switch carried on a rock shaft within the controller opens the circuit and cuts off the motive power of the entire train. It would be a comparatively simple matter to attach a braking device to the rockshaft, as indicated in the accompanying sketches. In Fig. 1, 1 and 2 are metal contacts that are part of the control trolley circuit; 3 is a forked switch-blade mechanically connected to sleeve 5 carried on rockshaft 6, but electrically insulated from sleeve 5 by an insulation body 4; 8 is an auxiliary finger also carried on the rockshaft and in a certain position of the rockshaft engages contact block 9, which is the negative end of a circuit including an electromagnet *M*, whose core can operate a valve *N* in a manner to allow train line air to discharge to the atmosphere.

When a motorman presses down the power handle knob and advances the handle to an operating position, blade 3 establishes connection between contacts 1 and 2, control current flows and all the car circuits begin normal operation. Fig. 2 shows the end view of the rockshaft and fingers in this position. Forked finger 3 engages contacts 1 and 2, but brake finger 8 is up in the air. If for any reason the motorman relaxes pressure on the safety button, fingers 3 and 8 take the position shown in Fig. 3, where the control circuit is open, but where finger 8 now backs up against block 9, thereby providing brake circuit *T-M-9* with a ground so that current can flow through it and cause the electromagnet to open the air valve. With this simple arrangement, the brake would act whenever the motorman released the button, whether the operating handle rested on an operating position or not; this would be a very undesirable condition, as it would then be impossible to throw the current off for coasting purposes under ordinary conditions of operation. It would not, however, be at all impracticable to so arrange a sleeve or lug of hard insulation for brake contact 9, so that when the power handle safety button is pressed down, it operates a mechanism that causes the insulating body to rise above contact surface of contact 9. By keeping the safety button down when returning the power handle to the off position (and this is the recommended method of throwing the power off except in cases of emergency) the emergency brake device would not operate, because the interference insulation block 10 would keep the brake circuit open. Any emergency occasion, however, calling for the release of the safety button, with the master controller operating handle on an operating position, would cause the action of the brake circuit and consequent stopping of the train, because the same movement that ordinarily turns the auxiliary trolley switch to its off position on such occasions would remove the interference insulation lug and allow finger 8 to ground block 9. It is evident that this device would require that the safety button be held down while the power is off and the train is coasting, as its release at any stage of operation of the master controller will remove the interference insulation block 10 and throw the brake circuit into action. Nor would it be wise to arrange otherwise without securing the equivalent of this, because the motorman is just as apt to be stricken while coasting as at any other time. In order to make it possible for the motorman to leave his post without operating the emergency brake attachment, it would be necessary to install a control trolley switch whose opening would render inoperative both the control and brake circuits. This switch would preferably be under the jurisdiction of the conductor rather than the motorman.

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MONOCYCLIC CURRENT FROM THREE-PHASE SYSTEM.

BY F. HARDIE JEANNIN.

The writer recently had occasion to operate monocyclic power mains from monocyclic and three-phase generators interchangeably, and resorted to a scheme that may prove interesting and useful to other engineers who may be confronted with such problems especially when a great deal depends upon their speedy solution with the material at hand, or with such additional material as may be easily and cheaply secured for temporary use.

The situation may be understood by referring to Fig. 1 where *A* is a 6600-volt three-phase generator at the water-power plant six and a half miles from the city; *B*, the sub-station in the city containing two 6100—1100-volt step-down transformers; *E*, the monocyclic generators in the steam station in the city, each having its own bus-bars; *H*, the city power mains; *I*, the power transformers; and *K*, the induction motors.

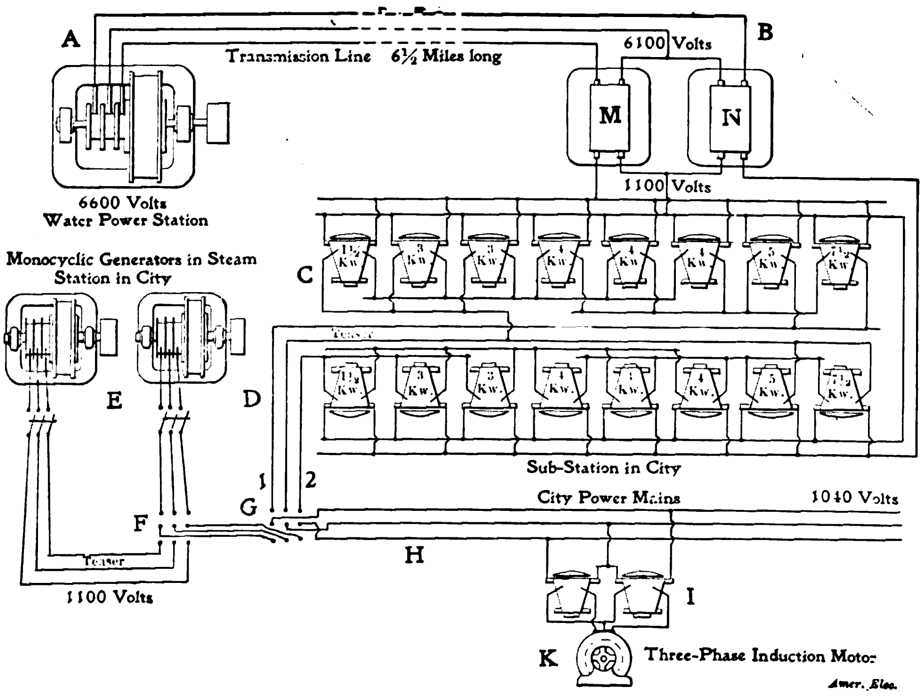


FIG. 1.—MONOCYCLIC CURRENT FROM THREE-PHASE SYSTEM.

It is evident that in order to work the two sub-station transformers at *B* to the best advantage, it was necessary to connect them in delta, and to take off the lighting load from the three phases equally; moreover, because of the ratio of the transformers, it was impossible to arrange them to form two legs of a "Y" connection.

Under these circumstances, it was necessary to run one of the monocyclic machines continuously for the motor load alone, which was very light for the greater part of the time. It will be seen by reference to Fig. 5 that the transformers *I*, Fig. 1, would have given nearly double the voltage if the power mains *H* had been thrown on the three-phase system without altering the connections so as to make them suitable for three-phase arrangement. This would necessitate changing the connections every time the mains had to be shifted from one station to the other in case either should fail. Such a procedure was, of course, out of the question, and the only thing to be done was to obtain another monocyclic system from the three-phase arrangement.

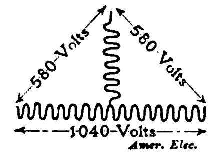


FIG. 2.

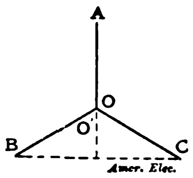


FIG. 3.

The requisites for doing this can be seen by referring to Figs. 2 and 3, where Fig. 2 represents the monocyclic generators and Fig. 3 the relation between two legs of a Y-connected and a monocyclic system. It may be seen from Fig. 2 that monocyclic mains and transformers cannot be used interchangeably with monocyclic and three-phase generators, because the voltage between the outside wires and the teaser is 580 volts for 1040-volt mains, while the voltage between each pair of wires is 1040 volts for a three-phase system. Standard 550—110-volt transformers are therefore furnished for monocylic systems, and 1040-volt transformers for 1040-volt three-phase systems.

Referring to Fig. 3 it will be noticed that when the points *B* and *C* are the same for both systems, the point *O'* for the teaser connection coincides very nearly with the neutral point *O* of the Y system; that is, *B O C* is so nearly like *B O' C* that it is practically the same, and hence, if *B O C* can be obtained, the power mains can be operated from the three-phase system. This was accomplished by using some new power transformers which were wound for 1040—2080 to 115—230 volts intended to replace the old transformers which were wound for 550 volts; for it was planned to shortly change over to 2300 volts, at the same time changing the monocyclic machines to three-phase, but it was not desirable to run the steam plant in the meantime for the power load alone.

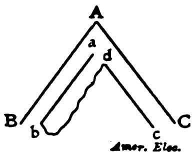


FIG. 5.

The number and capacities of the transformers are 2 of 7500 watts, 2 of 5000 watts, 6 of 4000 watts, 4 of 3000 watts and 2 of 1500 watts, making a total of 64,000 watts.

All of the transformers were wound so as to give 1040—2080 volts primary and 115—230 volts secondary.

The transformers were grouped and connected up as shown by *C* and *D*, Fig. 1. It was necessary for each group to give a total voltage of $1100 \div 1.73 = 636$ volts. The transformers had a ratio of $1040 \div 115 = 9:1$. Hence, there would be $1100 \div 9 = 123$ volts (or $2 \times 123 = 246$) on the secondaries when used as shown, and $123 \times 5 = 615$ volts from five secondaries in series, which for practical purposes is near enough to 636 volts.

The transformers must be so connected that the required current will flow through the entire series. To obtain this, the transformers were connected up in multiple series as shown in Fig. 1 by *C* and *D*, and separated into two equal banks. Fig. 4 shows the grouping of the transformers and the voltage and current for each step.

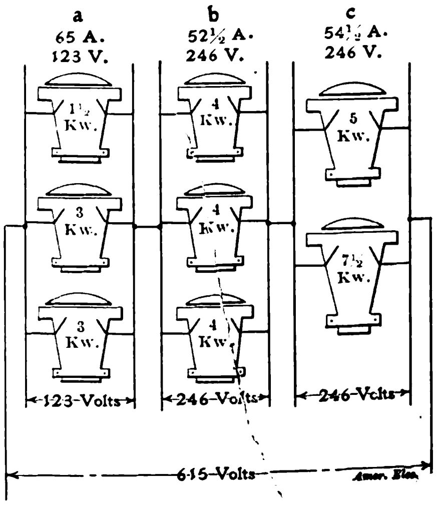


FIG. 4.—TRANSFORMER CONNECTIONS.

In group *a* the secondaries of each 3 kw. transformer are in multiple, which was necessary because the 1½-kw. transformers had only two leads and hence gave only 123 volts. In groups *b* and *c* the secondaries of each transformer are in series, giving 246 volts; hence, the three groups in series give $123 + 246 + 246 = 615$ volts. The current for normal load for group *a* is 65 amperes; for group *b* 52½ amperes, and for group *c* 54½ amperes. This is ample capacity, for the current required is $32000 \div 615 = 52$ amperes. The primaries are all connected in multiple, and to the supply mains by means of the transformers *M* and *N* Fig. 1. This is shown diagrammatically by Fig. 5, where *A B* and *A C* represent the primaries of the two banks *C* and *D* in Fig. 1, and *ab* and *cd*, the secondaries of the two banks. The teaser wire is taken off from the common connection of the two banks *C* and *D*, Fig. 1.

By putting in switches *F* and *G*, Fig. 1, the power circuit can be transferred to either monocyclic machine or to the three-phase generator. When the two banks were first connected to the power mains the motors ran in the wrong direction, which was corrected by reversing the two outside wires *1* and *2* in Fig 1. Of course, care had to be taken not to reverse the teaser and an outside wire.

When the change mentioned is made, the transformers in banks *C* and *D*, which are at the steam sub-station, will replace the present power transformers and the circuit will then be three-phase at 2080 volts.

INTERCOMMUNICATING TELEPHONE SYSTEMS.

The Clark Automatic.

BY A. DALLAM O'BRIEN.

The Clark automatic system is one of the class that uses a central switchboard containing a switching device for each instrument connected to the system, the switching being accomplished by means of a dial mounted at each instrument, the operation of the centrally located device being entirely automatic.

The dials one of which is located at each instrument, consist of a clockwork mechanism enclosed in a nickel case, and carrying on its face a cardboard disc covered with celluloid. The disc is divided into 75 parts, numbered from 1 to 74, the blank space corresponding to the home instrument. Fig. 1 shows this automatic dial.

The clockwork mechanism consists of two brass wheels turning about a common axis, each having 75 teeth mounted on a central axle. The top wheel is a dummy and is connected to the lower one by means of a spiral spring. A third and smaller wheel is also mounted on the same spindle, its function being to engage a retarding mechanism and thus regulate the speed of rotation of the lower of the two main wheels. In addition to this mechanism, a small plunger, shown to the left in Fig. 1, is mounted on the case and engages with a double locking lever, which is normally held in contact with the dummy wheel by means of a small spring, so that forward rotation is prevented. Backward rotation is prevented by a pawl, which engages each tooth of the dummy as it passes. The action of pushing in the plunger releases the dummy wheel from the locking lever, and at the same time, locks the lower wheel. The pointer shown in Fig. 1 is stationary, and is fastened to the casing of the dial. The cardboard disc is fastened to the central spindle and turns with it. The home point, which corresponds to the blank space on the dial and to the 75th tooth of the wheel, is mounted on the spindle and turns with the dummy wheel.

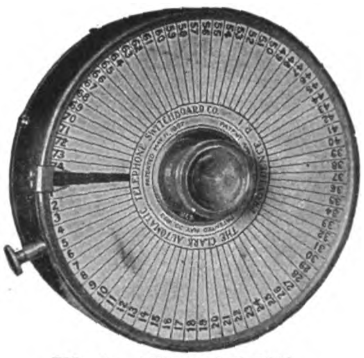


FIG. 1.—AUTOMATIC DIAL.

The operation of setting the dial to the number of any desired station is as follows: The plunger is pushed in, releasing the dummy wheel and locking the lower wheel at the same time, as has already been explained. The dial, spindle, dummy wheel and disc are then turned by means of the knob until the number on the dial corresponding to the desired station is brought under the pointer. When this has been accomplished, the plunger is released and the lower wheel, acting under the influence of the spiral spring, revolves until a pin on its rim engages with a similar pin on the rim of the dummy wheel, which causes the lower wheel to revolve through the same arc as the dummy.

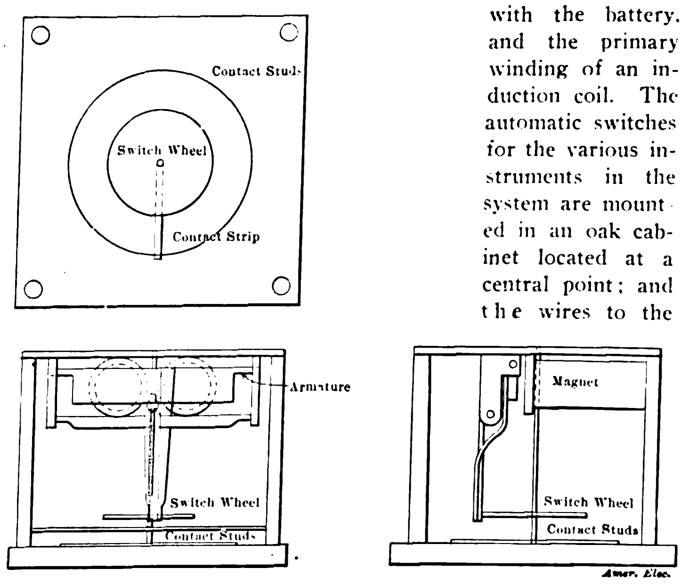


FIG. 3.—VIEWS OF BASE, SWITCH WHEEL AND CONTACT STUDS.

In the interior of the dial box is mounted a small contact spring, so placed that its point is normally between two teeth of the lower wheel, and only touches the teeth when the wheel is pulled forward by the spring. Making contact between a tooth on the lower wheel and the contact spring closes the circuit through a magnet mounted in the switching device located in the switchboard.

From this it will be evident that if the dial is turned so that the pointer rests on No. 10, the lower wheel will be moved so that 10 teeth will pass the contact point and the circuit will be made and broken ten times.

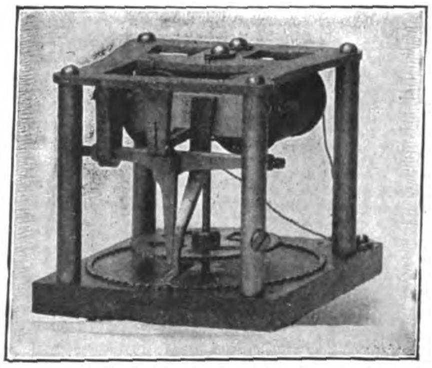


FIG. 2.—AUTOMATIC SWITCH.

The automatic switch consists of a red fibre base 4 ins. square, having 75 contact points, 74 of these points being terminals for other lines connected to the system, and the remaining terminal the home point. A frame supported by four posts carries a magnet, the armature of which is trunnioned to a second armature. This double armature has levers which engage a wheel to which is attached a German-silver spring rotating with it and making contact with each of the studs as it passes over it. Fig. 2 is a perspective view of the automatic switch, and Fig. 3 a front view, side view, and section showing the base, switch wheel and contact studs.

The instruments have a common return for the talking circuit, and a separate common return for the bells. They are equipped with local talking batteries at each station, the transmitter being in a local circuit with the battery, and the primary winding of an induction coil. The automatic switches for the various instruments in the system are mounted in an oak cabinet located at a central point; and the wires to the various switches run from terminals at the top of the cabinet, so that to connect an instrument to the switchboard it is only necessary to run two wires from the instrument to the board and connect them to the proper

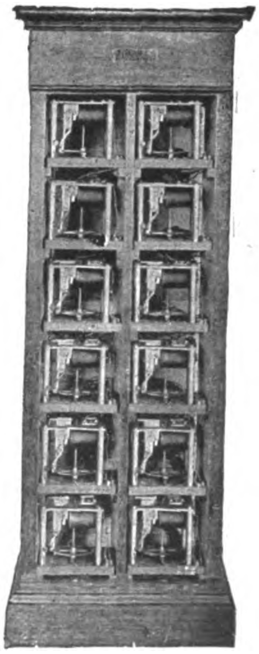


FIG. 4.—SWITCH CABINET.

terminals in the top of the cabinet. Fig. 4 shows an elevation of the switchboard cabinet with the front cover removed, so that the arrangement of the automatic switches in the interior may be clearly seen.

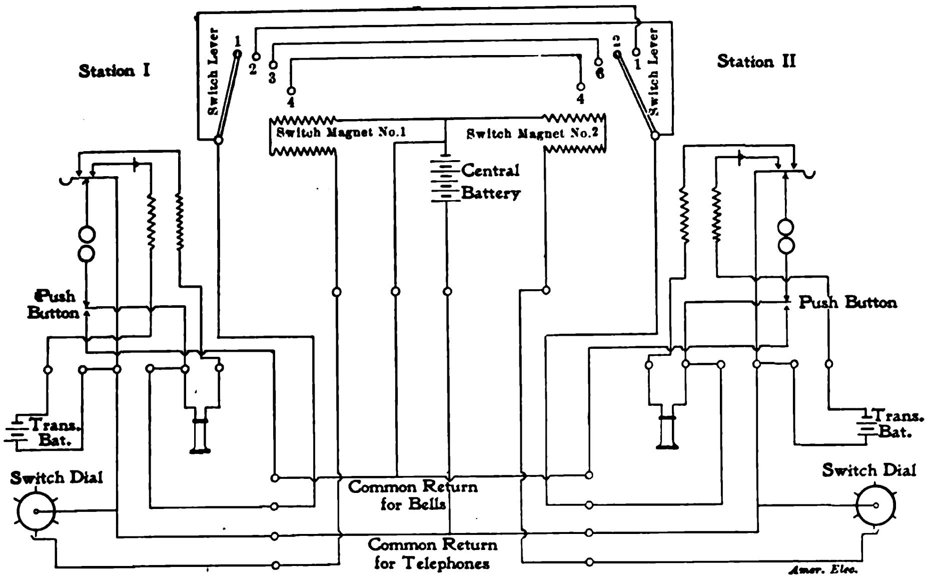


FIG. 5.—DIAGRAM OF CONNECTIONS.

In Fig. 5 is shown a wiring diagram for the system with vibrating bells and battery for calling purposes. The switch levers or contact strips on the automatic switches for the two stations, as shown in the diagram, are on the home points, but the method of operation will nevertheless be readily understood. Suppose, for example, that station *I* wishes to call station *II*. The switch disc at station *I* is turned so that space 2 is brought under the pointer. In performing this operation, the circuit from the central battery over the common return through the contact point of the dial, the line from the instrument to the switch, the switch magnet at *I* and back to the battery, is made and broken twice; and thus the switch magnet at *I* is caused to attract and release its armature twice and in so doing, moves the switch wheel through the space of two teeth by means of the lever attached to the armature, and brings the contact strip on the wheel into contact with stud 2. The push button at station *I* is then pressed, and current flows from the central battery over the common return for telephones to the hook-switch at station *II*, thence through the bell to the switch lever, over the line to the switch lever at station *I*, through the push button and back over the common return for bells to the central battery; thus signaling the required station. The removal of the hook-switch closes the local circuit through the transmitter battery and primary winding of the induction coil, and also closes the secondary circuit at the hook-switch. The secondary talking circuit between the two instruments is as follows: From the hook-switch at station *I* through the secondary and receiver in series to the switch lever, thence over line 2 to the lever at station *II*, through the receiver and secondary in series to the hook-switch, and back over the common return to station *I*; thus connecting the receivers and secondaries in series in the usual way. When conversation is finished and the receivers placed upon the hooks, the telephones are restored to their normal condition for receiving signals. However, the disc at station *I* remains in the position in which it was placed when the call was made. As the backward rotation of the dummy wheel is prevented, it will be readily seen that supposing the original call from station *I* to have been made for station *V*, and a subsequent call desired for station *II*, in order to obtain the connection it would be necessary to rotate the disc through more than one complete turn; this, however, involves little additional labor.

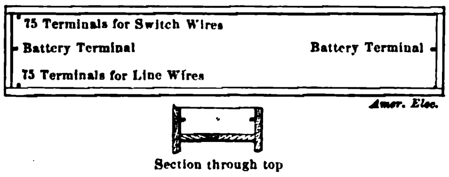


FIG. 7.—DESK TELEPHONE SET.

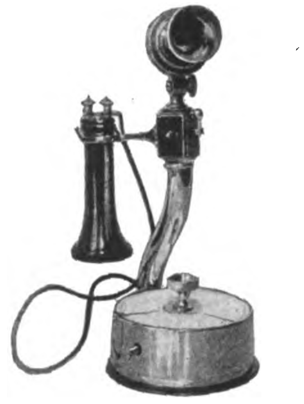


FIG. 7.—DESK TELEPHONE SET.

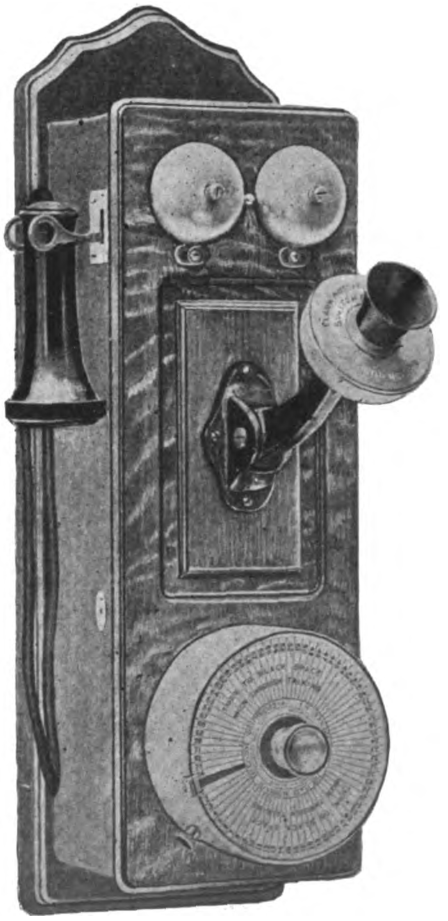


FIG. 8.—WALL TELEPHONE SET.

In addition to the terminals which are provided at the switchboard for the two wires from each instrument, two other terminals are provided and are located at either end of the board across which the central battery is connected. To one of them is connected the common return wire for the telephones, and to the other the common return wire for the bells and the wire from the common side of all the switch magnets.

Fig. 6 shows the arrangement of the terminals in the top of the board, the terminals themselves being of the usual lock-nut construction. The standard dial is 5¾ ins. in diameter, and is arranged for a maximum capacity of 75 stations.

The switchboards are made in standard sizes to accommodate 12, 18, 24, 36, 48 or 72 stations. The local batteries for the transmitters consist of two cells of some form of wet or dry battery, and the central battery for operating the switching mechanism and for signaling purposes, of from four to six cells, depending upon the distance through which it is desired to signal. When the stations are a considerable distance apart, and in consequence an excessive number of cells would be required for signaling purposes, the instruments are equipped with 10,000-ohm magneto generators and 80-ohm ringers. The method of wiring remains practically the same as in the case where vibrating bells are used.

In the desk set, which is shown in Fig. 7, the dial is mounted upon and forms a part of the base of the instrument. In the wall telephone, the dial is either mounted on the back board of the set or else fastened to the wall.

This system allows any number of independent conversations to be carried on at the same time without interference, and is owned and manufactured by the Clark Automatic Telephone Switchboard Company, of Providence, R. I.

TESTS OF MOTORS DRIVING MACHINE TOOLS.

BY MILES F. MOORE.

In the plant of the Morden Frog and Crossing Works, Chicago rails are cut, bent and planed, and made into frogs, crossings and switches for steam and street railway use. The tools and machines are of the strongest type, and the metal worked ranges from 10 to 60 carbon. As the old shop existed, it was a building 100 x 300, containing all the machinery, which was driven from a line shaft 250 feet long, by a simple Corliss engine of 125 horse-power. Being compelled to increase the plant, it was decided, after carefully testing the horse-power required to drive each machine or group of machines then in service, to install an electrical equipment, as it gave more facility in the arrangement of machinery and handling of material while cost of operation was but slightly increased. The alternating-current system was adopted.

The generating plant, as installed, consists of a Buckeye tandem compound engine of 300-h.p. direct-connected to a General Electric 200-k.w., 240-volt alternator, running at 200 r.p.m.

In the shops there are 15 Westinghouse, Type C, constant-speed motors of capacity shown in the accompanying table. This equipment has been in use for three months, and is proving very satisfactory, both in operation and in maintenance.

The load is very fluctuating, and the table will no doubt give those interested in this class of work an idea of the efficiency of this kind of equipment. The table has been carefully prepared from data taken under actual service by Mr. Ingraham, of South Chicago; Mr. Canney, of the Westinghouse Company, and the writer, and is believed by them to be correct. In connection with this table a short description of the work done under test should be taken into consideration.

The universal drill was tested by drilling a 1¼-in. hole through four inches of soft steel.

The line shaft, belt-driven from two 50-h.p. motors, operated tools specified in the table, working on the class of work described, and the test covered a period of about one hour.

The benders are belt-driven by individual 5-h.p. motors, and the test was the bending of 90-lb. A.S.C.E. rail, cold, to an angle of 15°.

The high-speed saw is belt-driven direct from a 50-h.p. motor, and the table carrying the rail was operated from the same source. The test consisted of sawing through an 85-lb. rail in 40 seconds.

The blower in the smith shop runs continuously 10 to 15 hours per day, and delivers air at 3 pounds pressure.

The pattern shop is entirely belt-driven, and during the test the machines were completely stalled without any appreciable increase in current.

With very few exceptions, the machines are belt-driven from motors or countershafts, which arrangement has been found to give best results, as it reduces the shock due to the reversal of machines.

This system was installed under the rules of the Department of Electricity of the City of Chicago, for direct-current wiring. Under these rules the wiring is capable of taking an overload of from 35 per cent to 50 per cent. It will be noticed, however, that the leads to the motors appear to be too small, under these rules. As a matter of fact, they are amply large, since the overload lasts but a few seconds, and as a matter of fact, there has never been a warm wire or warm motor. The great trouble has been to get fuses of proper carrying capacity for the excessive starting current, and with this problem there are some experiments yet to be made.

It is hoped by the writer that the table will give information that many want to know, and that those who want to know more will not hesitate to make themselves known to the writer, who will be glad to exchange ideas.

MORDEN FROG AND CROSSING WORKS—TEST OF ELECTRICAL EQUIPMENT.

G. E. Generator 200-Kw. 481 Amp's 230-240 Volts A. C. Westinghouse Type "C" Constant Speed Motors. 60 Cycle. 7200 Alt.

Size of motor.	Rating.	Line.	Size of line.	Size of lead.	Starting current.	Starting voltage.	Running cur. light.	Running cur. load.	Running cur. avg.	Running voltage.	Starting time.	Average devel. H.P.	R.P.M. of motor.	Tools operated by motors.
5 H.P.	200 V 15 A	East	1	8	55½	90	7½	7½	7½	220	10 sec.	3.82	1120	Radial drill—Niles universal.
20 H.P.	200 V 60½ A	East	1	1	163	125	22½	47½	35	220	20 sec.	17.84	840	14 in. pony planer—14 in. pointer—Band saw—Universal saw—Lathe—Grind stone.
10 H.P.	200 V 33½ A	West	00	6	87	85	12½	27	17½	220	7 sec.	8.93	840	Punch—3 single spindle drills—Emery wheel.
15 H.P.	200 V 42 A	West	00	4	125	175	15	40	30	220	10 sec.	15.30	840	2 15 ft. 36 in. x 36 in. Sellers planers.
5 H.P.	200 V 15 A	West	00	8	52½	100	4	8½	8½	220	10 sec.	4.34	1120	Rail bender—Am. Bridge Works.
5 H.P.	200 V 15 A	West	00	8	52½	100	4	8½	8½	220	10 sec.	4.34	1120	Rail bender—Am. Bridge Works.
5 H.P.	200 V 15 A	West	00	8	50	100	7½	14	11	220	5 sec.	5.65	1120	3 spindle rail drill—Newton.
7½ H.P.	200 V 22½ A	West	00	6	55	100	7½	14	11	220	10 sec.	5.65	840	3 spindle rail drill—Newton.
15 H.P.	200 V 42 A	South	300,000	4	125	175	15	40	30	220	10 sec.	15.30	1120	5 in. Beaudry hammer—5 in. Ajax forging machine.
5 H.P.	200 V 15 A	South	300,000	8	48	100	4	14½	14½	220	7 sec.	7.40	1120	Punch and Shear.
30 H.P.	200 V 83½ A	South	300,000	0	230	115	65	65	65	220	15 sec.	33.16	850	No. 3 Root high pressure blower—3 lbs. pressure.
50 H.P.	200 V 135 A	South	300,000	300,000	412½	100	32½	182	145	220	40 sec.	74.00	850	High speed saw cutting 85 lb. A. S. C. E. rail in 37 sec.
50 H.P.	200 V 135 A	North No. 1	0,000	0,000	450	150	50	90	70	220	25 sec.	71.42	850	12 switch planers—3.3 spindle drills—3 milling saws—1 punch and shear—1 bulldozer—1 rail bender—5 single spindle drills—1 bolt cutter—1 saw grinder—3 lathes—4 shapers—2 emery wheels—1 shear.
50 H.P.	200 V 135 A	North No. 2	0,000	0,000			50	90	70	220			850	

THE APPLICATION OF 4-AMPERE SERIES ALTERNATING ENCLOSED ARC LAMPS TO CITY LIGHTING.

BY J. HENRY HALLBERG.

In 1893 the first demonstration of the successful application of low-energy arc lamps to city lighting materialized when Fifth Avenue, New York, was equipped with 6-ampere open-arc lamps, operated 2 in series on 118-volt constant potential direct current circuit. These lamps were equipped with alabaster globes, and consumed about these 270 watts each at the arc. These lamps were later exchanged for enclosed arcs, operating on the same circuits. The commercial success of this and similar low-energy arc lighting systems led the city authorities of Cincinnati to specify 4-ampere alternating-current arc lamps for the streets and alleys of that city, and the 4-ampere series alternating-current enclosed arc lamp, fitted with light alabaster inner and clear outer globes, with porcelain enamel metal reflectors and solid copper shells, was adopted and installed by the Cincinnati Gas and Electric Company.

In the down-town district, no two lamps are more than 133 feet apart and there are two posts at each street intersection at diagonally opposite corners. The lamps in the over-head district are hung from 12 to 20 feet above the street, and are in no case more than 400 feet apart. The larger part of this magnificent installation, comprising 90 automatic constant-current 60-light transformers, 90 combination static dischargers and lightning arresters, 90 60-light switch panels and 4500 series alternating-current copper-cased arc lamps, with absolute cut-out hangers, is now completed, and the first circuits have been in operation about one year. The entire arc lighting system operates from 3-phase 4,500-volt 60-cycle generators. Switching devices and automatic transformers in the generating station are arranged in three groups, so that they can be switched on any of the three phases, and permit the proper balancing of the load.

The commercial efficiency of the system, exclusive of generators, lines and cables, is over 91 per cent. The initial power factor of the apparatus is between 70 and 75 per cent of all loads above ¼ load. Because of the capacity of the lead-covered cables connected to the apparatus, the commercial power factor of the entire system is maintained from 10 to 15 per cent above the initial power factor of the apparatus. Consequently the power factor of the installation is about 80 per cent. The current is maintained at exactly four amperes. The lamps are adjusted for about 75 volts at the arc. Each lamp consumes 240 to 260 actual watts at the arc, and is equipped with half-inch carbons. The life of one ½-inch carbon ten inches long is depended upon to be 115 hours. The trimming of 4500 lamps is taken care of by eight trimmers, who work on specially constructed tower wagons. The open-base inner globe is used, and all globes are cleaned at the sub-stations.

There are comparatively few outside of those interested in street lighting who understand the value of low-energy alternating-current arc lamps as applied to street lighting. Because of this, complaints may be expected from the public when a 9.6-ampere arc is replaced with two low-energy alternating lamps. When a change of this kind is made and established, however, the public soon realizes the advantages of a shadowless, well distributed and diffused light, and would not willingly go back to the old method of illumination.

The writer's experience at Cincinnati during the past year has established the following facts: The open-base inner globe is safer and more economical than the closed-base globe. The large metal reflector is not necessary on 4-ampere alternating-current lamps hung only 12 or 15 feet above the street, but a smaller enamel reflector immediately above the arc is beneficial.

The initial power factor of a 4-ampere series alternating-current system should not be counted as greater than 75 per cent. The 75-per cent power factor applies to ordinary overhead circuits. The power factor of the underground circuits at Cincinnati is maintained above 91 per cent. The efficiency can be maintained above 91 per cent and the regulation still be perfect. Four amperes is the lowest practical limit at which successful alternating-current arc lighting can be practiced, and ½-inch carbon is the most practical size for such lamps. Notwithstanding the large size of the carbons, the regulation of the system is perfect, and there are no objectionable shadows from the carbons.

[The foregoing is an abstract of a paper read at the convention of the National Electric Light Association, recently held at Chicago.]

◆

RELATION BETWEEN EFFECTIVE AND MEAN VALUES OF CURRENTS OR ELECTROMOTIVE FORCES.

BY J. J. CORT.

A neat and efficient piece of apparatus for illustrating experimentally the relation between mean and effective values of current or electromotive force consists of a copper disc mounted on a small fan motor. Two brushes press against the disc, so that a circuit is made from one brush to the other through the disc during one-fourth, one-half or three-fourths of a revolution, depending upon the position of brush 1. The heavy portion of the disc shows the non-insulated part of the copper plate, the light portion being covered with an insulating substance.

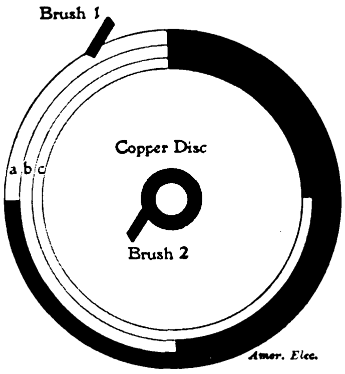
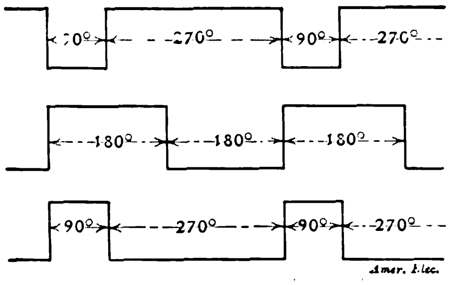


FIG. 1.—COPPER CONTACT DISC.



FIGS. 2, 3 AND 4.

If brush 1 be placed so as just to cover the path marked *a* and a continuous or direct current be sent through the brushes if the disc is caused to rotate, a pulsating current will flow which will have a wave form as shown, and will have a maximum value during three-fourths of a revolution and be zero during the remaining fourth. If brush 1 be placed on *b*, the pulsating wave of current will have a maximum value for one-half a revolution and be zero during the other half. If placed in *c*, the current will have a maximum value for only one-fourth of a revolution and be zero for the other three-fourths.

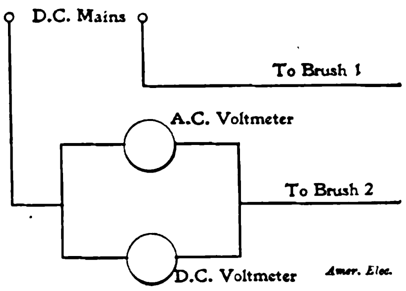


FIG. 5.—DIAGRAM OF CONNECTIONS.

A direct-current voltmeter placed in the circuit should measure mean or average values of e.m.f.; and an alternating-current voltmeter, the effective or square root of the mean square values. An ammeter may be used instead of the voltmeter, a direct-current and alternating-current instrument being used in series. It is simpler to use the voltmeters, on account of the smaller currents and the reduction in sparking.

With the connections as shown in Fig. 5, the following observations were made, the voltage between the direct-current mains being 114:

Contact.	Alternating-current voltmeter.	Direct-current voltmeter.
¾	96.5	83.5
½	75.0	53.0
¼	47.0	23.5

The ratio of the alternating current to the direct-current readings, or the ratio of effective to mean values as observed was,

$$96.5 \div 83.5 = 1.155 \text{ for } \tfrac{3}{4} \text{ contact,}$$
$$75.0 \div 53.0 = 1.415 \text{ for } \tfrac{1}{2} \text{ contact,}$$
$$47.0 \div 23.5 = 2.000 \text{ for } \tfrac{1}{4} \text{ contact.}$$

Assuming the impressed volts to have remained constant, the computed ratio of effective to mean values for the three cases are as follows:

For ¾ contact:

$$\text{Average value} = \frac{114 \times 3}{4} = 85.5 \text{ volts;}$$

$$\text{Effective value} = \sqrt{\frac{114^2 \times 3}{4}} = 99 \text{ volts;}$$

$$\text{Ratio} = 99 \div 85.5 = 1.157.$$

For ½ contact:

$$\text{Average value} = \frac{114}{2} = 57 \text{ volts;}$$

$$\text{Effective value} = \sqrt{\frac{114^2}{2}} = 80.6 \text{ volts;}$$

$$\text{Ratio} = 80.6 \div 57 = 1.414.$$

For ¼ contact:

$$\text{Average value} = \frac{114}{4} = 28.5;$$

$$\text{Effective value} = \sqrt{\frac{114^2}{4}} = 57;$$

$$\text{Ratio} = 2.$$

NOTES ON RAILWAY FEEDER PROBLEMS.

BY WM. A. DEL MAR.

The feeder problem is a matter of great importance in the economic design of an electric railway, but like many other engineering problems, it is not susceptible of accurate solution. It is well known that the total working cost of a conductor during any given time is the sum of two items—the value of the energy wasted in it and the interest on its original cost. The ideal feeder system is one in which these items are adjusted so that their sum is a minimum. To make the adjustment accurately, it is necessary to have much data that cannot possibly be obtained with a great degree of exactness. It is for this reason that the solution of the feeder problem is only an approximate one. Taken broadly this problem includes not only the selection of certain conductors to convey current to the cars, but also such matters as the location of the power house and the system to be employed. Commercial and other outside consideration complicate this part of the problem to such an extent that its solution is not a matter of mere engineering. The system which will be most economical has to be carefully worked out for each particular case by someone of experience. Scheme after scheme must be tried until the best is found.

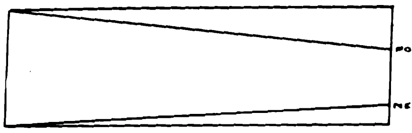


FIG. 1.

This article treats only of the direct-current feeders which supply current to the cars, it being assumed that the power station or sub-station has been already located. The feeders may be divided into two classes, the positive and negative systems. The positive system consists of a contact wire or rail supported by insulators either overhead or close to the ground, and a number of conductors which convey energy from the positive bus-bar of the station to the wire or rail. The negative system consists of the track rails and the conductors which carry the current from them to the negative bus-bar of the station.

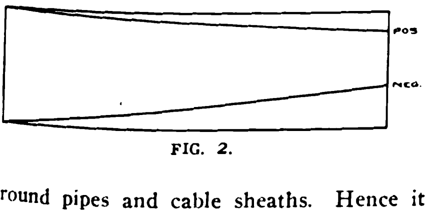


FIG. 2.

The drop of potential in the negative system is determined by considerations of power and feeder economy, and also by the possibility of the electrolysis of underground pipes and cable sheaths. Hence it often occurs that the negative system is made such a good conductor that the drop of potential in it is small compared with that in the positive system. Such a case is shown in Fig. 1. A case in which the drop in the negative system is greater is shown in Fig. 2, the total drop being the same in both cases. This kind of diagram also shows the difference of potential between the positive and negative systems at every point. It is, however, more usual to show the drop of potential in the two systems as illustrated in Fig. 3.

When the conductors of a circuit are all of copper, the circular mil (circ. mil) may be used as a unit of conductivity. A copper wire one foot long, having a sectional area of one circ. mil, has a resistance of about 10½ ohms. When there are several metals used in the same circuit, it is customary to compare the conductivity of the other metals with that of copper. The conductivity of the iron conductors is expressed as that of a copper conductor having the same resistance.

When the resistance per foot of a number of conductors in multiple is wanted, add their equivalent circ. mils of copper and divide 10.5 by the sum. Thus, the resistance per foot of the following four conductors in multiple—1,000,000 circ. mils, 2,500,000 circ. mils, 1,500,000 circ. mils, 250,000 circ. mils—is $10.5\div5{,}250{,}000=0.000002$ ohm. This being clear, the next matter to consider is the economy of conductors.

Kelvin's law that for the most economical section of conductor, the annual interest on capital outlay should equal the annual cost of energy wasted in transmission, is an interesting application of mathematics to electrical engineering, but unfortunately its use in railway feeder work is limited by many practical considerations. It is, however, of value as a check in cases where it cannot be used to compute the most economical drop of voltage. The cross-section of metal in either the positive or the negative system must usually be assumed before the other can be determined.

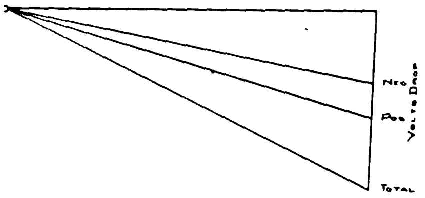


FIG. 3.

The negative system is a good conductor on account of the bonded rails. The positive system has not this advantage, and if the contact conductor is a trolley wire, the number of circ. mils is very small if the auxiliary conductors are not taken into consideration. The positive system is therefore, much more liable to be overheated by the current than the negative, and for that reason, requires more auxiliary metal. On the other hand, it is cheaper to put in the bare cables for the negative system than the insulated ones required for the positive system. Moreover, the drop through the negative part of the circuit is limited by the possibility of damage to pipes, etc., by earth currents, which does not have to be taken into consideration for the positive part of the circuit. It is, therefore, probably best to find the smallest number of circ. mils that will do for the positive system, and after having added something in order to have a margin for safety, find the circ. mils required for the negative system. To start with, the following data must be tabulated.

a, Circ. mils required in the positive system,

b, Ohms per ft. in the positive system $= 10.5 \div a$,

c, Length in feet from the power station to the center of the load.

d, Resistance of positive system from power station to load center $= b\times c$,

e, Average watts per car (or train),

f, Number of cars (or trains) in the section.

Potential differences V between the positive and negative systems at the load center must be assumed and the following quantities worked out for several values of this potential difference. The power station voltage may be called E.

g, Amperes per car (or train) $= e\div V$,

h, Volts drop in positive system $=g\times f\times d$,

i, Volts drop in negative system $=E-V-h$,

j, Circ. mils of copper in negative system $=(10.5\times f\times g\times d)\div(i\times b)=\dfrac{a\times h}{i}$

k, Area of bonded rail in equivalent circ. mils of copper,

l, Number of rails in multiple,

m, Total circ. mils of rails $= l\times k$.

n, Additional circ. mils of copper required $= j-m$.

It would be well to estimate here the best size of cable to use in order to know how many are required. This depends upon the facilities for their transportation, handling and installation and must be determined for each particular case. Suppose the circ. mils per cable, Q, to be decided upon, then

p, The number of cables $= n\div Q$,

q, The total length of cable $= p\times c$,

r, The cost per foot of cable (dollars),

s, Total cost of cable $= q\times r$.

t, Percentage rate of interest on cost of cable plus percentage for maintenance and depreciation,

u, Annual cost of cables $=\dfrac{s\times t}{100}$,

v, Loss in kilowatts for one year,

w, Value of kilowatt-year (dollars),

x, Cost of energy lost per annum $= v\times w$,

y, Total annual cost $= u+x$.

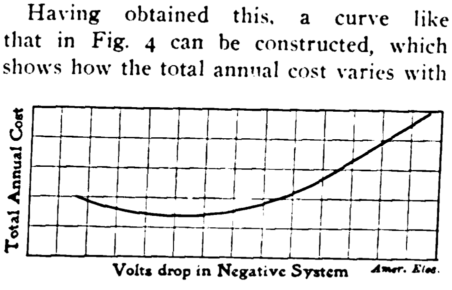


FIG. 4.

Having obtained this, a curve like that in Fig. 4 can be constructed, which shows how the total annual cost varies with the drop in the negative system. This curve shows for what drop the total annual cost is least. This will serve as a guide in the design of the feeder system, but any attempt to follow it exactly would be futile. Had the drop in the negative instead of that in the positive system been assumed, an analogous method would show the most economical drop in the positive system.

In the above calculations, a load center was found and the load assumed to be concentrated at that point. This was quite right for the purpose, but for certain other calculations the load must be taken as distributed along the line. It is usual, when the interval between successive cars or trains is small, to assume the current to be distributed and to be so many amperes per foot of line. The curve of current is then a straight line, as shown in Fig. 5, the ordinate at any point giving the current taken by all of the line beyond that point.

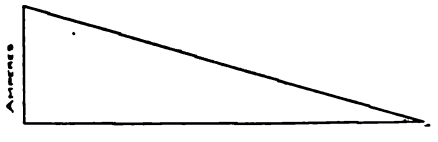


FIG. 5.

The drop of potential may or may not be made to follow a straight line law. If the drop of potential is uniform, as shown in Fig. 6, the curve of circular mils is also a straight line sloping from the power station where the circ. mils equal full current×10.5÷volts drop per foot, to the end of the line where the circ. mils become zero. From this the circ. mils at l feet from the station equal 10.5×current at that point÷volts drop per foot. Such a curve is shown in Fig 6, where the method of approximating to it is also indicated. This method consists in using a number of cables as shown by the dotted lines.

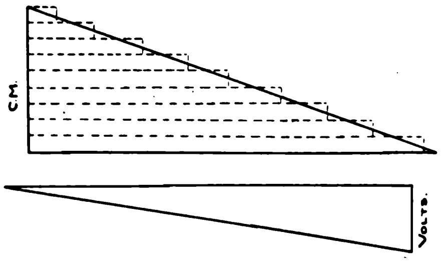


FIG. 6.

For a uniformly distributed load and a given drop of potential from the station to the end of the line there is a certain way of arranging the feeders so that the amount of metal in them shall be a minimum. In order to accomplish this, the circ. mils at a distance of l feet from the end of the line most distant from the station must be equal to 7 × sq. root of total length of line×current at the station× sq. root of l÷volts drop from the station to the end of the line. All of these quantities, except l, are constants for a given case, so that the formula may be written: k × sq. root of l, where k equals 7 × sq. root of total length of the line×current at station÷volts drop from the station to the end of the line. If the circ. mils be calculated by this formula for a number of points, it will be found that a parabolic curve is obtained, as shown in Fig. 7. An approximation to this is shown by the dotted lines. When the approximation is adopted, the resulting drop of potential should be calculated in order to see that it is not far from the assumed value.

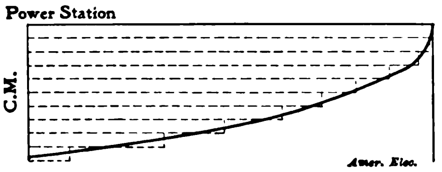


FIG. 7.

There is one case in which this formula is useless; it is when the current density in the feeders is so great as to cause overheating. In this case, the most economical amount of metal that can be used is the smallest amount that will carry the current without overheating; of course in this case, the drop of potential will be less than that desired.

The most useful formula in feeder calculations is that which gives the drop of potential when the resistance is known. Assuming the amperes per foot and ohms per foot of line to be constants, the drop of potential from the end of the line farthest from the power station to a point l feet from that end is ½×amperes per foot× ohms per foot×l^2. This formula can only be applied directly if the resistance per foot is the same everywhere. As this is not usually the case, a simple but indirect method of getting the drop must be employed. Suppose the line to be divided into three sections, *AB*, *BC* and *CD*, each of which has a different resistance per foot, the point *A* being that farthest from the power station. Then the drop of potential in *CD* equals the drop from *A* to *D*, less the drop from *A* to *C*, assuming the resistance per foot of the whole line to be the same as in *CD*. These values are obtained by the formula given above. Similarly, the drop in *BC* equals the drop from *A* to *C* less the drop from *A* to *B*, assuming this time that the resistance per foot of the whole line is the same as in *BC*. Finally, the drop in *AB* is obtained directly from the formula. The total drop of potential from *A* to *D* is the sum of the drops in *AB*, *BC* and *CD*. The

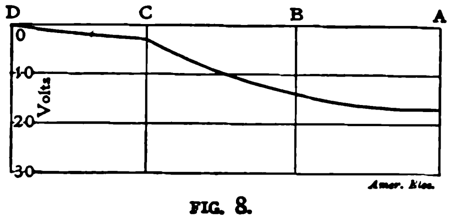


FIG. 8.

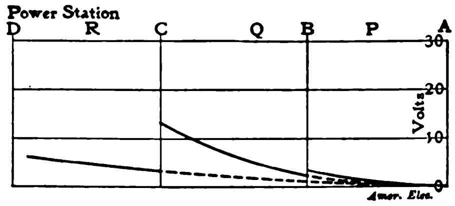


FIG. 9.

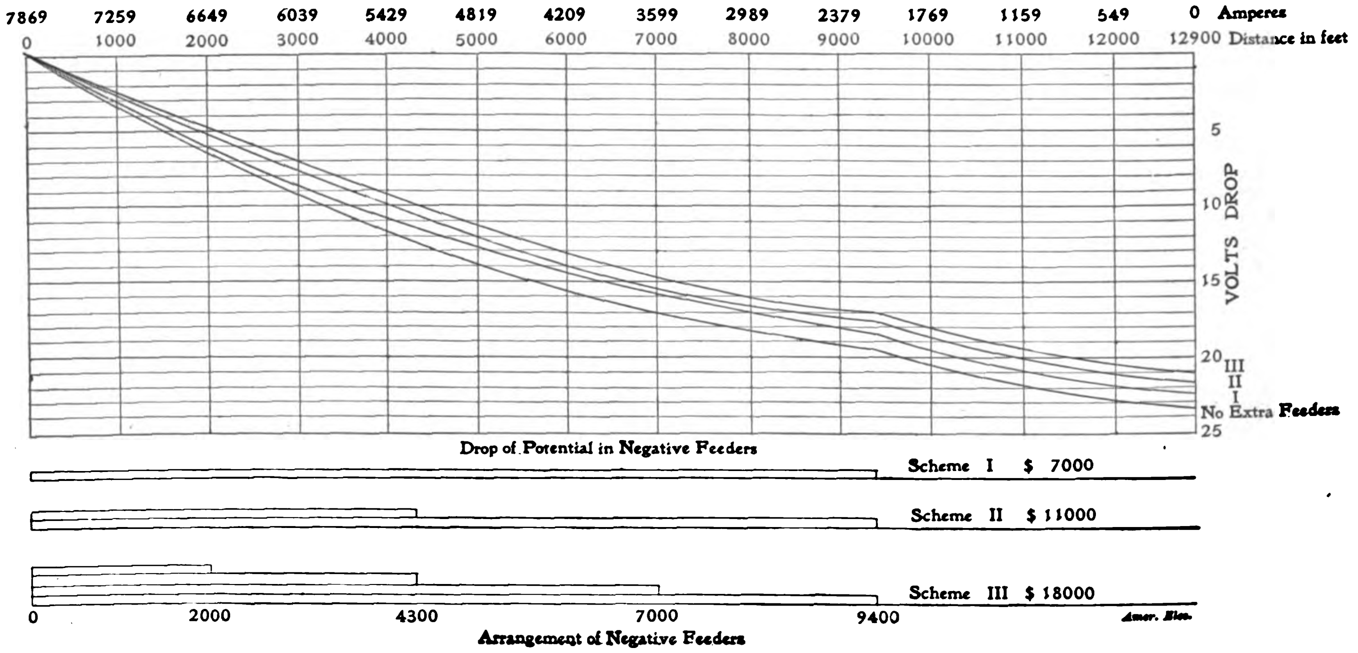


FIG. 10.—POTENTIAL CURVES.

same method gives the drop from the end of the line to any point. Suppose, for example, that the drop from D to P is wanted where P is a point in BC. Then the drop from P to C equals the drop from A to C less the drop from A to P, supposing the resistance per foot of the whole line to be the same as in BC. The drop from D to P equals the drop from D to C plus the drop from C to P. A slide rule can be used to work out the drop by this method, and thus curves of potential can be obtained in a few minutes. Fig. 8 illustrates the method described above. The equation of the curve AB is volts drop fromt A to $P = \frac{1}{2} \times$ amperes per ft. $\times$ ohms per ft. in AB and AP^2, where P is any point in AB. The equation of the curve BC is volts drop from A to $Q = \frac{1}{2}$ amperes per ft. $\times$ ohms per ft. in $BC \times AQ^2$, where Q is any point in BC. In the same way, the equation of the curve CD is volts drop from A to $R = \frac{1}{2} \times$ amperes per ft. $\times$ ohms per ft. in $CD \times AR^2$, where R is any point in CD. The parts of the curves drawn in full are the useful portions. The curve AD, Fig 9, shows all of these useful portions put together and is the curve of potential drop of the whole line. Some examples of potential curves are given in Fig. 10, which shows a line 12,900 feet long on which the current is 0.61 ampere per foot. The first 4300 feet from the station has a cross-section of iron equivalent to 25,000,000 circ. mils of copper; the second, 23,000,000; and the third, 20,000,000. The lowest curve shows the drop of potential under these conditions. Curves I., II. and III. show the drop of potential when the iron is supplemented by 1,250,000-circ. mil cables distributed as shown in schemes I., II. and III. respectively.

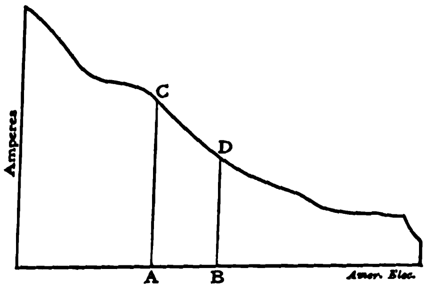


FIG. 11.

When curves of this sort are wanted for some particular railway, a map of the line should be drawn to a scale of about 400 feet to the inch. This map should show the number of trolley wires or contact rails along the line and the number of tracks or other iron-work in the negative return. This being complete, the circ. mils of copper, or the equivalent of iron. may be noted for various parts. From these figures the resistance per foot of the line may be obtained by assuming the efficiency of the bonding to be from 95 to 100 per cent.

There is a general method by which it is possible to obtain the drop of potential in a section of conductor however the current may be distributed in it. In Fig 11 is a curve showing the distribution of current over a railway line on which the load is not evenly distributed. The ordinates give the amperes in the feeders at every part of the line. The drop in the section AB is equal to the resistance per foot of $AB \times$ area $ABCD$ expressed in ampere-feet. This area may be measured by means of a planimeter. If the planimeter reads in square inches, and the amperes and feet are plotted respectively to the scales of a amperes to the inch and f feet to the inch, the reading of the planimeter must be multiplied by $a \times f$ to get the area in ampere-feet.

One advantage this general method has over the special one described before, is that it enables the drop from the power station end to be determined directly; whereas. the other formula gives the drop from the far end of the line.

If the assumed volts drop to the end of the line does not give the drop to the load center required by Kelvin's law, other values must be assumed until the required drop of potential to the load center is approximately obtained. However, it may be impossible to use this value on account of an excessive drop to the end, resulting from having the desired drop to the load center.

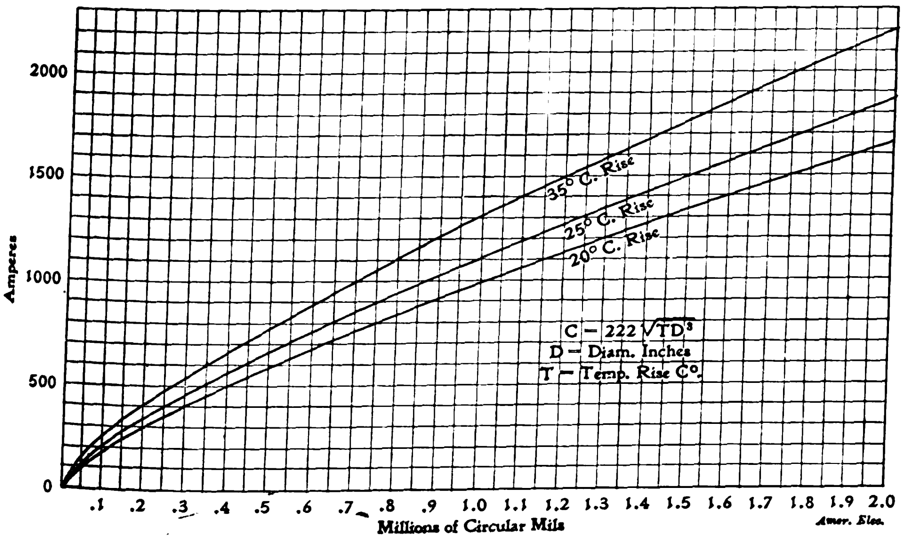


FIG. 12.—CURVES FOR DETERMINING SIZE OF CABLE.

Fig. 12 will be of service in determining the proper size of cables. The three curves shown give for bare copper cable exposed to air the allowable current for different diameters and for rises of temperature of 20°, 25°, and 35° Centigrade respectively. For exposed weather-proof cable, 78 per cent of the current values given by the curves should be used, and for lead sheathed cables in ducts, 70 per cent.

It must always be borne in mind that the feeder problem is so complex that no simple method will give a direct solution, and the best system to use in any particular case must be found by trial; hence, the above notes are only intended to indicate briefly how such trial values may be obtained.

Lessons in Practical Electricity

SWITCHES.

Electric circuits are completed and broken, interconnected and separated, by means of appliances known as "switches." The simplest form of switch is a metal strip fastened at one end and arranged so that the other end may be pressed upon a metal plate or screw-head, or similar contact piece. Such a switch is known as a "push-button," the strip being pressed down by means of a china or rubber button. Fig. 1 illustrates this class of switch. It is only suitable for circuits carrying minute currents—¼ ampere or less, because the contact surface is necessarily small and the contact poor.

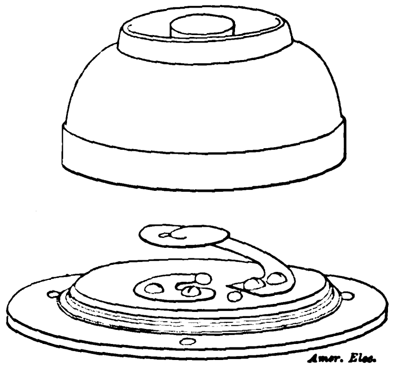


FIG. 1.—PUSH-BUTTON.

The current-carrying parts of switches must have enough metal in them to prevent the temperature of any part from rising more than 50° Fahrenheit when carrying full load. This makes it necessary for the contact parts to have from 0.01 square inch to 0.05 square inch of area for each ampere to be carried, depending upon the material used and the form of construction.

It is a well-known fact that it is easier to bring two surfaces into intimate contact by rubbing them together than it is by simply pressing them together. This kind of contact is obtained by a form of switch known as a "knife" switch, so called because it opens and closes like the blade of a jack-knife. With this arrangement, it is possible to obtain ample contact surface between the blade and the jaws, and at the same time the rubbing action keeps the contact parts bright and clean. A simple form of knife switch is shown in Fig. 2.

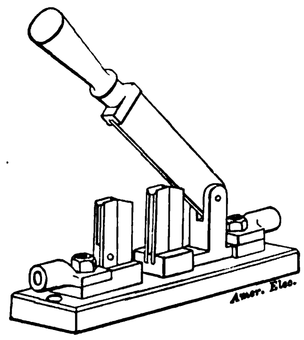


FIG. 2.

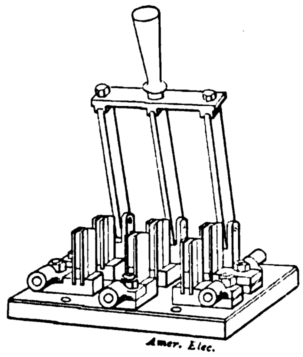


FIG. 7.

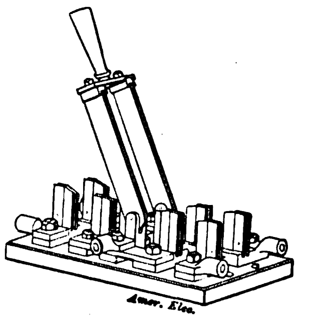


FIG. 11.

The switch proper is mounted on a base, which is made of marble, slate or some other fire-proof insulating material. The base must be strong, so that there will be no danger of it cracking or breaking on account of the heating effects of arcs or on account of mechanical strains, both of which are liable to be severe in the case of large switches. The parts of a switch that carry current are made of copper or brass; preferably the former for ordinary service. The blade enters between two clips, which are springy and press tightly against it, so as to afford good contact. In order that the clips shall be flexible, they are either made of several thicknesses of metal or of one piece slit up into several parts. It will be noticed that the contact pieces are shaped so that, when the switch is opened, the break is made along the entire length of the jaws, in order that the arc may not concentrate at the last point of contact and melt it away or burn it badly.

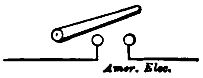


FIG. 3.

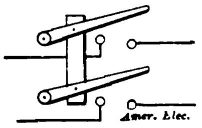


FIG. 6.

The object of having a double break is to divide the arc into two parts. When a circuit is opened at two points in series at the same instant, the e.m.f. which produces the arc is divided between the two breaks, and consequently the arc is reduced one-half both in intensity and length of duration. Another advantage that is gained by having the switch made in the form shown is that the hinge is not required to carry any current. When, however, the hinge has to carry current, it must be equipped with spring washers held by lock-nuts or pins so arranged that a secure connection will be maintained at all positions of the switch blade. It would not be advisable to provide more than two breaks for each pole, because it would greatly complicate the construction, and, moreover, it would be almost impossible to make more than two contacts separate at exactly the same time; and unless they do, no gain is made over the two-break arrangement. The switch shown in Fig. 2 and diagrammatically in Fig. 3, is called a single-pole, single-throw switch.

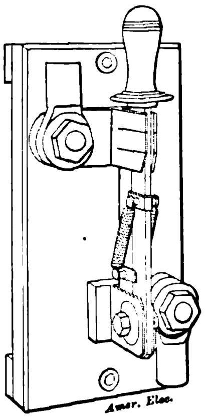


FIG. 4.

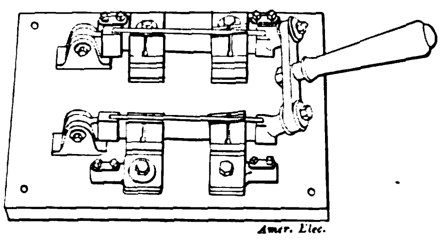


FIG. 5.

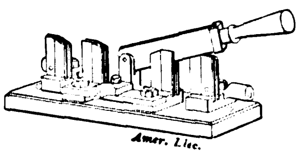


FIG. 9.

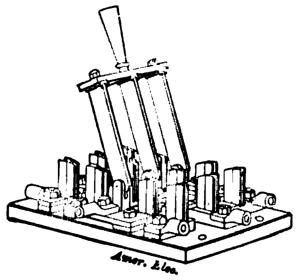


FIG. 13.

For very heavy circuits, "quick-break" switches are used. A single-pole switch of this type is shown in Fig 4. A principal or leading blade is attached directly to the handle, and a second blade is attached to the leading blade by means of a stiff coil spring. When the leading blade is withdrawn from the clips to an angle of about 30° its heel releases the following blade which is then forcibly opened by the spring being under tension, thus making an extremely quick break. Both blades are of equal carrying capacity.

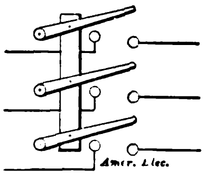


FIG. 8.

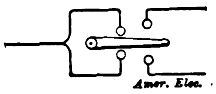


FIG. 10.

For constant-potential circuits, a form of switch called the double-pole switch, is universally used. It is shown in Fig. 5 and diagrammatically in Fig. 6. By reference to the figures it may be seen that the circuit is broken in four places at the same time when the switch is opened. For three-wire circuits, three-pole switches like the one shown in Fig. 7 and diagrammatically in Fig. 8, are used. It is similar to the one shown in Fig. 5, except that it has three poles instead of two, both switches being of the double-break type.

There is a general class of switches known as double-throw switches. A switch of this kind is used whenever one circuit is to be opened and another immediately closed, or when one or more connections are to be quickly transferred from one circuit to another. A single-pole switch of this type is shown in Fig. 9 and diagrammatically in Fig. 10; a double-pole switch, in Figs. 11 and 12; and a three-pole switch in Figs. 13 and 14. All of the switches shown in Figs. 9 to 14 inclusive are of the double-break type.

On switches carrying less than about 500 amperes, single blades are used for each pole; on switches carrying more than that, it is customary to use multiple blades for each pole, the number of blades depending upon the current to be carried. The single-pole switch shown in Fig. 2 has only one blade, while that in Fig. 15 has three blades. By this means, more contact surface is obtained with the same amount of metal in the blades; for the particular case shown in Fig. 15 there is three times as much contact surface as there would be if the metal of the three blades were put into one blade of equivalent cross-section.

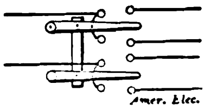


FIG. 12.

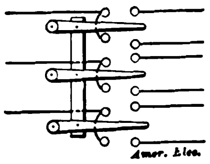


FIG. 14.

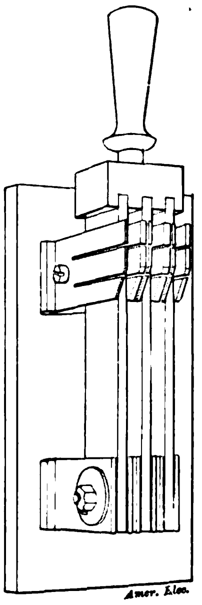


FIG. 15.

The handle of a switch must always be perfectly insulated from the current-carrying parts, even if the switch is only to be used for low-tension circuits. When cross-bars are less than three inches long, they should be made of insulating material. When greater than three inches in length, they may be made of metal, provided they are sufficiently separated from the jaws of the switch to prevent arcs following from the contacts to the bar when the switch is opened. As an additional precaution, metal bars should be covered with insulating material. The following table shows the proper spacings for switches to be used on direct-current systems, and which, therefore, would be safe for alternating-current circuits.

On switchboards, the spacings given for 250 volts direct current may be used for 440 volts alternating current. On a circuit of more than 300 volts, it is always a good

	Minimum separation of nearest metal parts of opposite polarity.	Minimum break distance.
125 Volts or Less.		
For switchboards and panel boards:		
10 amperes or less	¾ in.	½ in.
11 to 25 amperes	1 in.	¾ in.
26 to 50 amperes	1¼ in.	1 in.
For individual switches:		
10 amperes or less	1 in.	¾ in.
11 to 35 amperes	1¼ in.	1 in.
36 to 100 amperes	1½ in.	1¼ in.
101 to 300 amperes	2¼ in	2 in.
301 to 600 amperes	2¾ in.	2½ in.
600 to 1000 amperes	3 in.	2¾ in.
126 to 250 Volts.		
For all switches:		
10 amperes or less	1½ in.	1¼ in.
11 to 35 amperes	1¾ in.	1½ in.
36 to 100 amperes	2¼ in.	2 in.
101 to 300 amperes	2½ in.	2¼ in.
301 to 600 amperes	2¾ in.	2½ in.
600 to 1000 amperes	3 in.	2¾ in.
251 to 600 Volts.		
For all switches:		
10 amperes or less	3½ in.	3 in.
11 to 35 amperes	4 in.	3½ in.
36 to 100 amperes	4½ in.	4 in.

plan to have an auxiliary device to open the circuit, the switch being only used to close it; if the current is more than 100 amperes some such auxiliary device *must* be used. Switches for three-wire systems must have the break distance which would be used for circuits of the potential of the outside wires.

Fig. 16 shows diagrammatically the way in which double-pole, single-throw switches are used to connect feeders to bus-bars for a two-wire system. Fig. 17 shows the same thing for a three-wire system, using three-

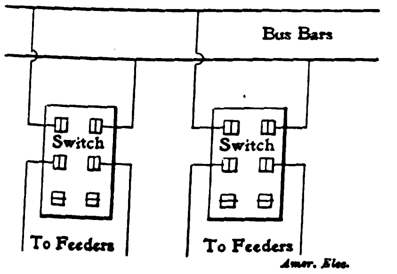


FIG. 16.

pole, single-throw switches for the purpose. Two sets of feeders are shown for each case. It will be seen from the figures that

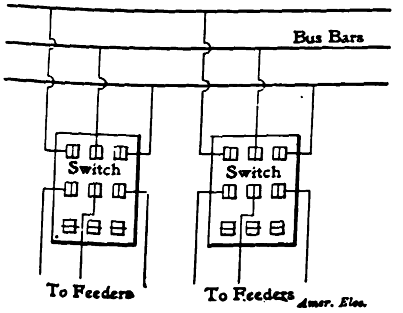


FIG. 17.

the connections are made so that the switches are thrown upward in order to close them; otherwise, they might fall shut under the influence of gravity and close the circuits to the feeders when it would be undesirable. Switches must be arranged so that gravity will not tend to close them.

When it is desirable to have two dynamos arranged so that either one can be connected to the bus-bars of a two-wire circuit, a double-pole two-way switch may be advantageously used. A diagram of the connections is shown in Fig. 18. When the switch

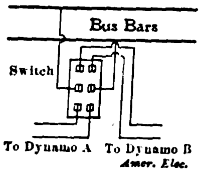


FIG. 18.

is in its mid-position, both dynamos are entirely disconnected from the circuit; when it is thrown downward, dynamo *A* is connected to the bus-bars; when it is thrown upward, dynamo *B* is connected to the bus-bars.

When more than two dynamos are used for a three-wire system, they are arranged to work in parallel on each side of the sys-

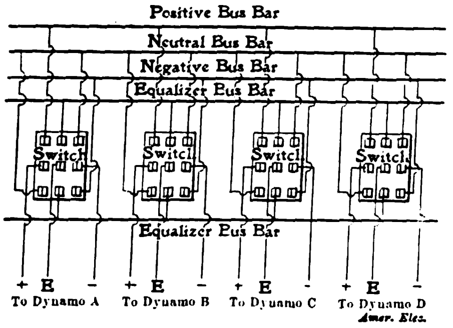


FIG. 19.

tem. A three-pole, two-way switch is used for every dynamo circuit in order that each one may be connected to either side of the system. Fig. 19 shows the connections for four dynamos arranged in this manner. It will be seen from the diagram that, when a switch is in its mid-position, the dynamo controlled by it is entirely disconnected; when it is thrown upward, its dynamo is connected between the positive and neutral bus-bars and to the upper equalizer bus-bar; when it is thrown downward, the machine is connected between the neutral and negative bus-bars and to the lower equalizer bus-bar.

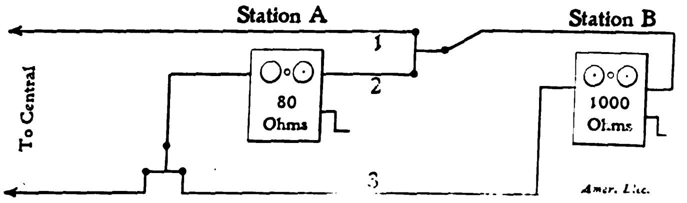


FIG. 1.—MR. GUILBERT'S SOLUTION.

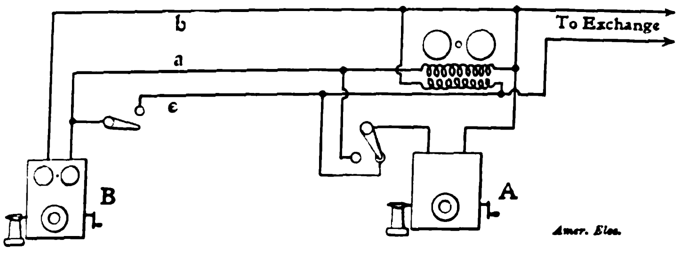


FIG. 2.—MR. MALCOLM'S SOLUTION.

Letters on Practical Subjects

Telephone Connection Problem.

To the Editor, American Electrician:—

The accompanying diagram (Fig. 1) is submitted as a solution of Mr. C. H. Temple's problem published in the April number of the AMERICAN ELECTRICIAN. Station *A* is equipped with an 80-ohm bell, and station *B* with a 1000-ohm bell, and the two stations are normally connected in parallel by three-point switches, the levers of which are arranged to touch both contacts when in the center, as indicated diagrammatically in the sketch. With the connections thus arranged, when a signal is sent out from the exchange the 80-ohm bell at station *A* takes practically all of the current by reason of its relatively low resistance, so that the sneak current passing through the bell at station *B* is not sufficient to operate it. Should station *A* wish to call up the exchange, the switch lever is thrown to the left, leaving the circuit to station *B* open; should station *A* desire to call up station *B*, this switch is thrown to the right, opening the line to the exchange. The switch at station *B* is similarly manipulated; as drawn in the diagram, it would be thrown downward for signaling to station *A* and cutting out the exchange, and thrown upward to cut out station *A* and signal the exchange.

Los Angeles, Cal. JOHN GUILBERT.

To the Editor, American Electrician:—

The sketch submitted herewith shows one method of fulfilling the conditions specified in Mr. Temple's problem, which appeared in the April number of the AMERICAN ELECTRICIAN. The push-buttons are shown diagrammatically as strap switches in order to simplify the sketch; the one at station *A* is a two-way or double-contact button, the one at station *B* is of the simple single-contact type. The two push-buttons normally occupy the positions shown in the diagram. The bell at station *A* is provided with two small windings so connected that when both are in circuit they act differentially, or in opposition to each other. With the circuits in the condition shown, the exchange and station *A* can signal to each other without affecting the bell or instruments at station *B*; and station *B* can signal to station *A* without affecting the apparatus at the exchange. In order to signal and talk from station *A* to station *B* the switch is thrown to the left, connecting the generator and telephone set at station *A* across the wires *a* and *b*, and leaving the line, *e*, to the exchange open at both stations. Should station *B* wish to call the exchange, the push-button at that station is closed, putting the wires *a* and *e* in parallel, and thereby putting in circuit both of the windings of the bell at station *A;* these being connected differentially, the signal from station *B* does not ring the bell at station *A*. This arrangement has also the advantage that should station *A* be talking to station *B*, the exchange can still signal to station *A*, since one of the bell windings is constantly connected across the wires *b* and *e*, and the switch at station *B* would be open during such a conversation. There is also the advantage that with the switch at station *B* closed, that station and the exchange can signal each other without affecting station *A*. This arrangement has the further advantage that no adjustments are necessary to prevent sneak currents from giving false signals.

George W. Malcolm.

Brooklyn, N. Y.

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Mr. Merrick's Question of Switches.

To the Editor, American Electrician:—

I enclose herewith a diagram constituting a solution of Mr. Merrick's problem in switch arrangement published in the May number. For the sake of clearness in the diagram, as well as convenience in drawing, simple double-throw knife switches are shown at each landing. When all the switches are closed downward, none of the lights will be in circuit. Throwing upward the switch on the first floor puts in circuit the lights on that floor and on the floor above. Throwing the second-floor switch upward will extinguish the lights on the first floor and connect up those on the third floor and leave the lights on the second floor connected. Similarly, throwing the third-floor switch upward extinguishes the lights on the second floor, leaves those on the third floor burning and connects the lights on the fourth floor. On this floor, throwing the switch upward extinguishes the lights there and on the floor below. With the switches all thrown upward the same cycle can be repeated by throwing them downward one by one, beginning either at the first floor and going upward or at the fourth floor and going downward.

New York. C. H. Pool.

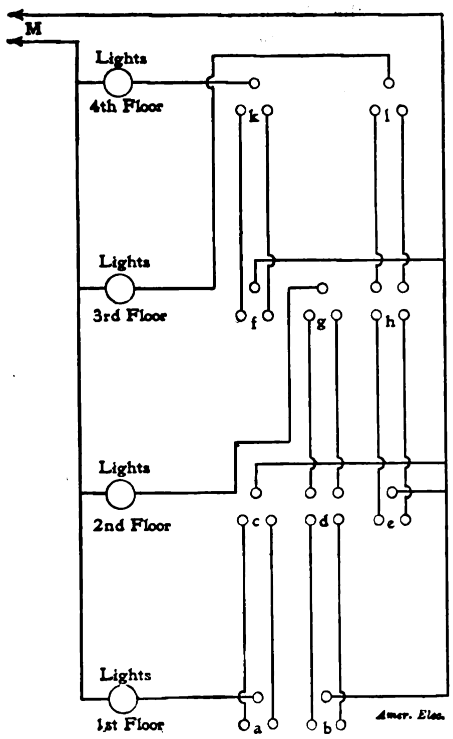

FIG. 1.—MR. SNYDER'S SOLUTION.

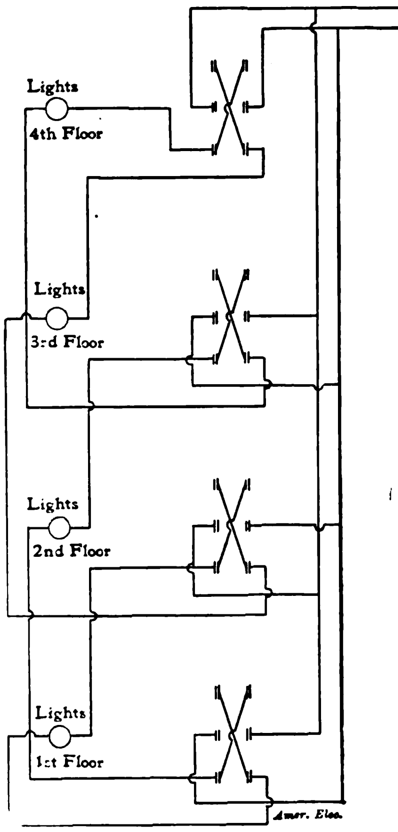

FIG. 2.—MR. MARSHALL'S SOLUTION.

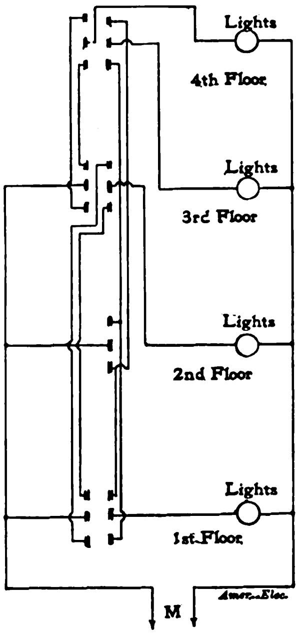

FIG. 3.—MR. POOL'S SOLUTION.

To the Editor, American Electrician:

The enclosed diagram is a solution of Mr. Merrick's switch problem, which was published in the May number of the American Electrician. The switches are of the ordinary three and four-point type. It will be seen by reference to the diagram that the lamps on the first floor may be lighted or extinguished by throwing into proper position switch *a* on the first floor or switch *c* on the second floor. The lamps on the second floor may be lighted or extinguished by means of switch *b* on the first floor, *d* on the second floor, or *g* on the third floor. The lamps on the third floor may be lighted or extinguished by means of switch *e* on the second floor, *h* on the third floor, or *l* on the fourth floor. Finally, the lamps on the fourth floor can be lighted or extinguished by either switch *f* on the third floor or *k* on the fourth floor. This solution does not entirely fulfill Mr. Merrick's requirements, because three switches are used on the second and third floors and two on the first and fourth. However, it is very convenient on account of the fact that, so far as the control is concerned, the lights on one floor are entirely independent of those on the others. At the same time, the operation of the system is not materially complicated by having several switches instead of one.

Santa Paula, Cal. H. N. Snyder.

[Substantially the same solution was received from Mr. Jas. B. Dillon, Louisville, Ky.—Editor.]

To the Editor, American Electrician:

The accompanying diagram, Fig. 1, is submitted as a solution of Mr. Merrick's problem in switch arrangement, which was published in this department of the May number. A standard type four-point switch would be used on each landing, but in order to make the diagram clear the connections are shown for double-throw knife-switches. When the switches are all thrown downward, the lights on all the floors will be out. If the switch on the first floor is thrown upward, the lamps on the first two floors are lighted. If the switch on the second floor is thrown upward, the lamps on the first floor will be extinguished and those on the third floor lighted, while those on the second floor will be left burning. In like manner, throwing the switch on the third floor upward puts out the lamps on the second floor, lights those on the fourth floor, and leaves the ones on the third floor burning. Finally, throwing the switch upward on the fourth floor extinguishes the lamps on all the floors. The same cycle can be repeated by throwing the switches downward one by one, beginning either at the fourth floor and going downward, or at the first floor and going upward.

San Francisco. John J. Marshall.

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Mr. Cerny's Experience With Atmospheric Electricity.

To the Editor, American Electrician:—

Referring to Mr. F. W. Cerny's letter in the May number, I wish to suggest the following hypothesis as to the cause of the clicking in his test receiver after disconnection from the power line. The power line acted as a collector of atmospheric electricity during the storm, and when the telephone set was connected to it through the test receiver and galvanometer it gave up its static charge, which produced the loud clicking in the receiver and the violent deflections of the galvanometer. A part of the discharge passed into the ordinary telephone set which acted as a condenser, and when the power line was disconnected this charge was given up, most of it passing directly to the ground and the remainder through the test receiver to the atmosphere.

Rockford, Ill. T. N. Slocum.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Can two transformers of the same type, but different sizes, such as a 25-light and 75-light, be operated in multiple with safety to both transformers? H. A.

This is usually possible, but it is not good practice.

What size of trolley wire is ordinarily used on modern street railways? J. McA.

No. 0 hard-drawn copper for short lines where the speeds are not high, and No. 00 or No. 000 for longer lines and high speeds.

In the wiring formula,

$$\frac{2D \times I \times 10.7}{V} = \text{circ. mils},$$

does the letter D represent the distance covered by one wire or both wires of a two-wire circuit? H. C. J.

The single distance. Thus, if each wire is 1000 feet long, there will be 2000 feet of wire in the circuit, but the value of D will be 1000.

How can it be determined whether the connections between a rotary converter and its transformers are correct for the direction of rotation given to the machine in starting up, before throwing the machine into circuit? E. C.

Bring the machine up to speed by means of its starting motor and test each phase independently with synchronizers, synchronizing the three simultaneously. If three synchronizers are not available, you can use two series banks of lamps for two of the phases and the regular synchronizer for the other one.

Is the e.m.f. of an inductor type generator truly alternating, or does it merely rise and fall between zero and maximum always with the same polarity? (2) Does the magnetic flux through the armature coils of such a machine alternate, or is it pulsating always in the same direction? J. W. C.

The e.m.f. is alternating; it is impossible to produce a unidirectional e.m.f. without the use of a commutator or the type of construction commonly known as unipolar. (2) The magnetic flux through the core and coils is always in the same direction, merely increasing and decreasing in strength as the inductor teeth approach and leave the poles.

What would be the effect of inserting a condenser in series with the secondary winding of an induction coil? O. H. D.

The condenser would doubtless be punctured and ruined. If one could be built to withstand the enormous potentials of such a circuit, and it were adjusted so that with a given frequency of vibrations at the interrupter the reactance of the condenser was equal to that of the secondary winding, a condition of resonance would be produced and the current in the secondary circuit would therefore follow Ohm's law and probably be increased to such a strength as to overheat and damage the secondary winding.

A re-wound bipolar motor hums much more loudly than before the armature was rewound. Could the rewinding cause the difference? (2) How can the humming be stopped G. E. M.

Not unless the new winding differed from the old one so as to increase the speed very considerably; if this was the case, the humming would be more perceptible, because it would have a higher pitch. (2) It can probably be modified considerably by painting the surface of the armature core heavily with shellac, so that the varnish will soak in between the core discs at the edges and thereby reduce the opportunity for vibration.

A 125-volt motor, rated at 96 amperes, but carying a load of only 30, sparks slightly at the brushes, and the sparking causes the commutator segments to be eaten away gradually at the edges. The circuit e.m.f. is 115 volts, but the motor is marked for 125 volts. What is the cause of the commutator trouble? D. E. H.

Either the brushes are improperly set, or the motor field is too weak. You can doubtless improve its operation by having the shunt coils rewound with wire one size larger than the present wire, making the winding of exactly the same depth in inches from the core outward that the present winding is. This will cause considerable reduction in speed, however.

What is the proper way to connect an ammeter with a standard instrument for calibration? (2) What is the simplest reliable method for calibrating such an instrument? W. J. S.

Connect the two instruments in series. (2) The best method is to use a storage battery, coupling the cells all in parallel and adjusting the current by means of either a water rheostat or a submerged coil rheostat. If the e.m.f. of a single cell is not sufficient to give the desired range of readings through the rheostat, twice the number of storage cells will have to be used, putting the cells in series in pairs, and connecting the pairs in parallel. The scale should be calibrated both ascending and descending as a check.

What are the meanings of the expressions "ampere-turns" and "ampere-feet"? L. R.

Ampere-turns are the product of the number of turns in a coil, and the number of amperes flowing through it. The number of ampere-feet of an electrical conductor is the product of the length in feet and the current flowing in the conductor. In lighting and power circuits where there are two or more wires, the number of ampere-feet is usually the product of the distance, or the length of one wire, and the amperes in one of the wires. For example, if in a three-wire three-phase circuit each of the wires was 1000 feet long and the current 50 amperes in each wire the circuit would have 50,000 ampere-feet.

Can a choke coil be used between a rotary converter and its transformers so as to protect the machine in case it is thrown in when not in absolute synchronism? (2) Which is preferable, synchronizing with lamps or by means of a synchroscope? (3) Which is the best practice when synchronizing with lamps, to have the lamps lighted or dark when the machine is in synchronism? C. M.

Such a precaution could be used and might be advantageous, but there should not be any necessity for it with modern appliances for synchronizing. (2) The synchroscope, or any synchronism indicator. (3) It is safer to synchronize with the lamps bright, because a broken filament will not mislead one into throwing the machines together at the wrong time.

A multipolar 100-kw. generator gives trouble at the commutator at intervals of two or three days, a burned spot appearing which covers about two segments of the commutator; this produces violent sparking and necessitates thorough sandpapering of the commutator. The machine has been running for about ten years, and the commutator has been turned off until the bars are about ⅛ inch thick at the ends; the thickness at this point was originally about 1½ inches. What is the probable cause of the trouble? F. G.

The machine evidently needs new commutator segments. The trouble is probably due to a slightly imperfect fit between the segments where the trouble occurs, and at the depth to which the segments have been cut down, so that the insulation, being slightly softened by the heat, becomes rapidly disintegrated at this point.

Why is a shunt strip used on the series winding of a dynamo? (2) When three machines are to be operated in parallel, what is the best way to determine whether the shunt on each machine is properly adjusted?

In order to adjust the degree of compounding; by lengthening the shunt strip the series winding is strengthened, and the machine can thus be made to increase its voltage as the load increases. (2) The compounding of machines operated in parallel cannot be satisfactorily adjusted by means of the individual shunts on the series windings. After the machines are put in parallel the series windings are all in parallel also; consequently, the shunt strips are also in parallel, and the adjustment of any one shunt will affect the series windings of all of the machines.

How much water is required per hour for the operation of a water motor under a given head? (2) How can water pressure be determined from the cubic contents of a reservoir? E. W. D. C.

The required quantity of water is given approximately by the formula

$$\frac{3{,}174{,}600 \times h.p.}{H \times eff.} = cu.\ ft.$$

In this formula, H is the head in feet, and *eff.*, the efficiency of the motor in percentage. (2) This cannot be determined from the cubic contents of the reservoir. The pressure per square foot at any point on the side of the reservoir, if the wall is vertical, may be found by multiplying the distance from the point on the wall to the surface of the water by 62.3.

TELEPHONE EQUIPMENT OF THE MANHATTAN ELEVATED RAILWAY.

In order to facilitate the transaction of business between the several departments and to provide a means of direct communication between the superintendent in charge and all portions of the road, the Manhatten Elevated Railway Company, of New York City, has installed a central energy telephone system having a maximum capacity of 600 lines. The system operated by the company has not as yet displaced the telegraph, although some dispatching and controlling of trains is done by telephone. It is expected, however, that in the near future the telephone will practically supersede the telegraph.

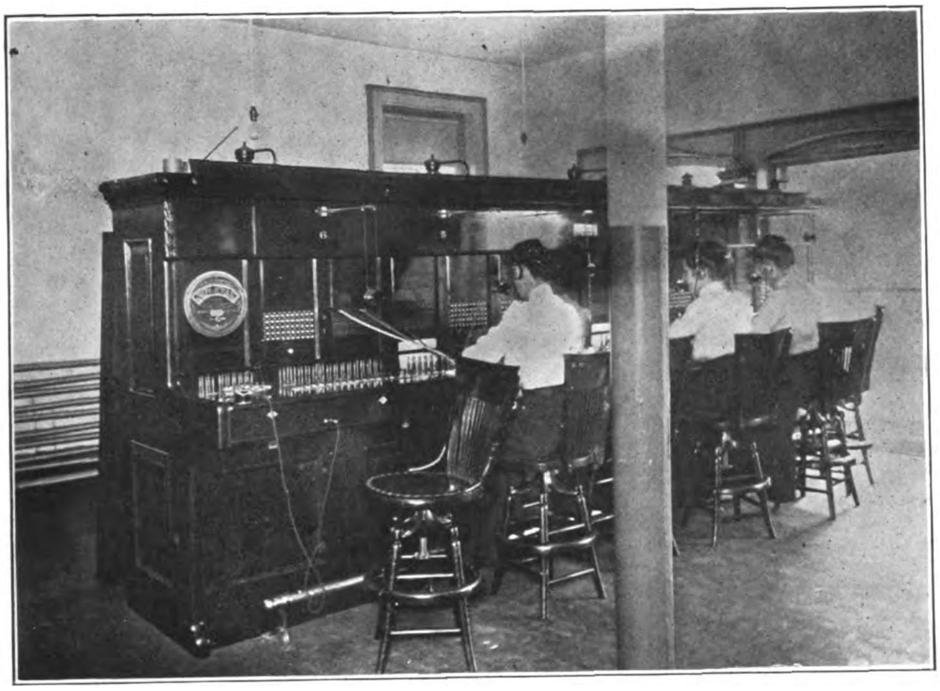

FIG. 1.—MANHATTAN RAILWAY TELEPHONE SWITCHBOARD.

The central is located at Ninety-eighth Street and Third Avenue, the operating room containing, besides the switchboard, the distributing frame, fuse rack, relay and coil racks, and the wire chief's desk. The system is of the double-supervisory signal type, lamps being used for line signals.

Power is obtained from a motor-generator outfit situated in a room adjoining the operating room and consisting of a 5-h.p. G. E. induction motor direct-connected to a Holtzer-Cabot generator delivering current at 30 volts. The induction motor receives current at 390 volts from the substation at Ninety-ninth Street and Third Avenue, and the output of the generator is stored in a battery of Type E-11 chloride accumulators. The ringing current is obtained from a motor-generator set of Holtzer-Cabot manufacture, the motor receiving its current from the storage battery, and the generator delivering alternating current at 75 volts and 15 cycles. The entire generating outfit, including storage batteries and the motor-generators for delivering the ringing current, is in duplicate. The switchboard, a view of which is given by Fig. 4 herewith, is provided with two voltmeter switches arranged so that the voltage of the charging machines and also the voltage of each individual storage cell can be read. Three ammeters are also installed, two for indicating the charging current from either machine and the other to indicate the current delivered at the switchboard. A recording wattmeter measures the amount of power received from the sub-station. Switches are arranged in the center of the board for charging either set of storage batteries and for connecting the batteries to the fuse panel. The board also contains under and over-load circuit breakers to protect the batteries when charging. In the lower left-hand portion of the board switches are arranged for controlling the ringer sets. A diagram of the switchboard connections is given by Fig. 2.

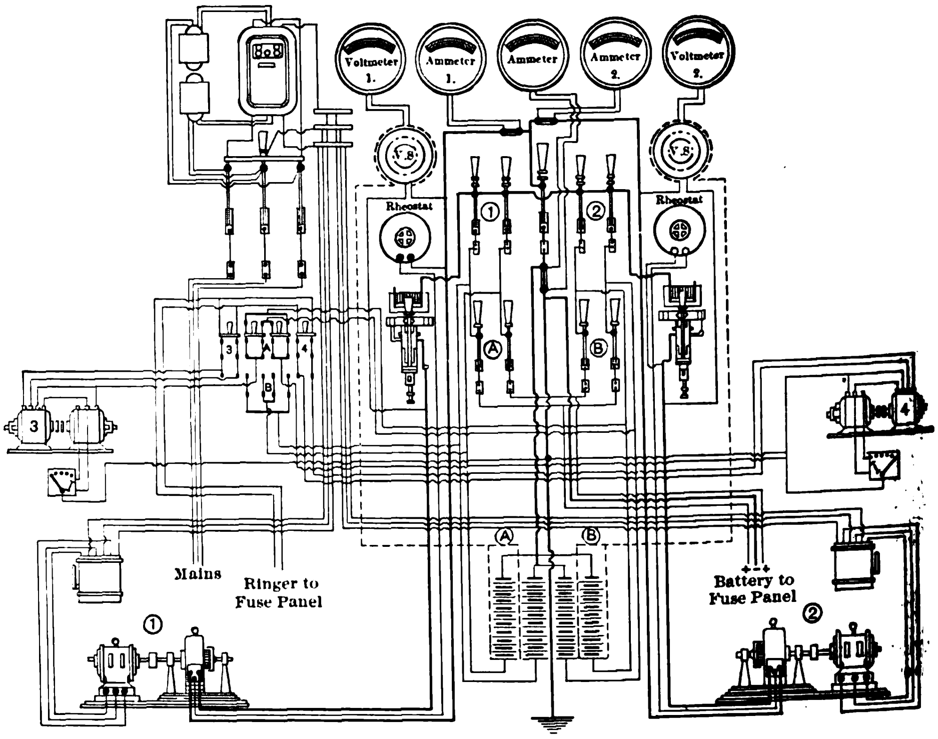

FIG. 2.—DIAGRAM OF POWER SWITCHBOARD CONNECTIONS.

The telephone switchboard, shown by Fig. 1, is built of mahogany, the front and back panels being removable so as to render all parts easy of access. The board is arranged for an ultimate capacity of 600 lines, 300 lines being at present installed. Six operators' positions are provided, each position containing 15 pairs of interconnecting plug circuits consisting of double-supervisory signals and combination ringing and listening cams. The cords are of three colors—white, brown and green—each cord being of a different color than the one adjacent to it. The incoming lines run to one side of the distributing frame, which is placed in the rear of the board, and are jumped across to the other side, whence they connect with the relays and the jacks. The battery is connected to the fuse panel, where fuses are provided for each cord circuit and all other principal leads.

The operation of the board is substantially as follows: The removal of the receiver from a subscriber's hook causes the line lamp to light, and this lamp remains in that condition until the operator inserts her plug in the jack, when it is extinguished. After ascertaining the number desired, she inserts the mate of the plug in the jack of the desired subscriber and presses the ringing key. The insertion of the plug in the jack of the called subscriber lights a supervisory lamp which remains lighted until the called subscriber takes his receiver from the hook. When both lights are extinguished, it is a sure indication to the operator that conversation is being carried on over the line, and when the lamps are lighted again it is an equally sure indication to the operator that both receivers have been hung upon the hooks and that connection is no longer desired, whereupon she removes the plug.

The switchboard is also provided with a testing section, on which is mounted a voltmeter and cord circuits for making ordinary tests on the lines. In front of the switchboard is the wire chief's desk, which is so arranged that the person in charge can act as a monitor as well as wire chief.

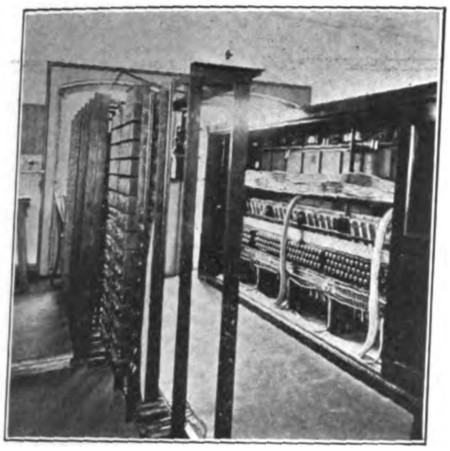

FIG. 3.—REAR VIEW OF TELEPHONE SWITCHBOARD.

The desk is provided with cord circuits and necessary connections for observing the condition of service, and also has a complete testing outfit, whereby any special tests may be made.

The outside wiring consists of lead-covered cables ranging in size from 5 to 120 pairs. These are suspended from a galvanized guy wire fastened to the elevated structure with iron brackets or hangers. The cables are hung to this guy wire with marlin and are pot-headed at each station, the wires being brought to binding posts mounted on hard-rubber strips in a neat oak junction-box placed inside of the station waiting room. This construction permits of rapid testing and arranging of all connections. The telephone cables are carried in underground ducts at 110th Street and Fifty-third Street to the elevated structures on the west side, and at Ninety-ninth Street to the elevated structure on Second Avenue. All the cable work was installed by the Manhattan Railway Company under the supervision of Mr. W. H. Kinloch, who is in charge of the system. The entire system was designed and installed by the Lambert-Schmidt Manufacturing Company.

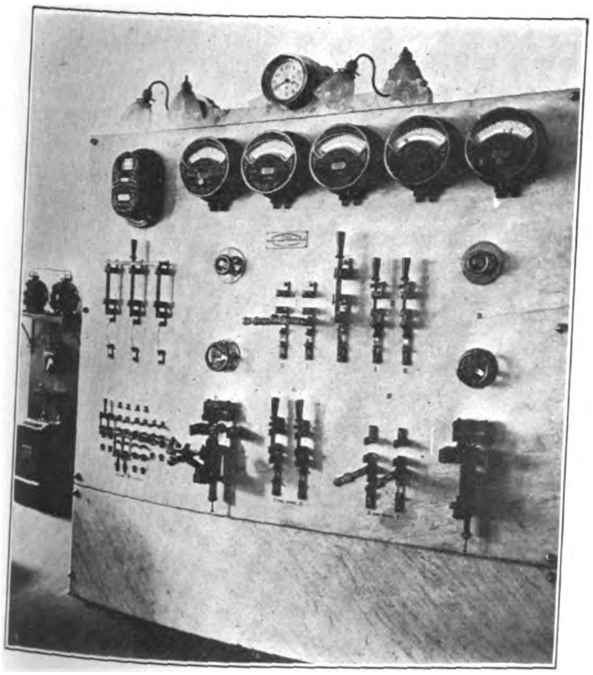

FIG. 4.—POWER SWITCHBOARD.

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THE NEW ALLIS-CHALMERS GAS ENGINE.

In view of the recent announcement of the acquisition by the Allis-Chalmers Company of the American rights for the manufacture of the Nuremberg double-acting gas engine, a brief description of this engine as built by the original manufacturers, the Augsberg & Nuremberg Machine Company, will doubtless be of interest to American engineers.

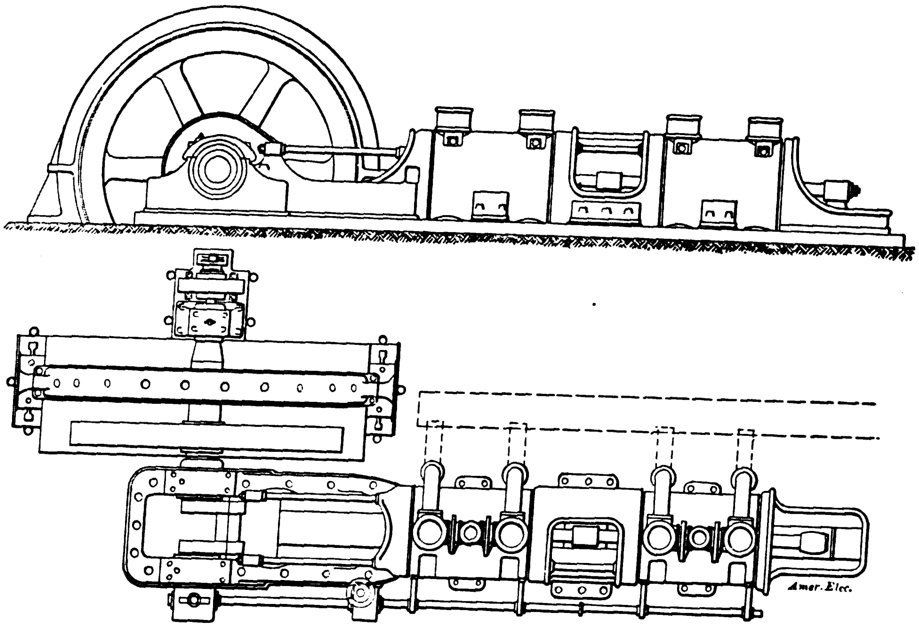


FIG. 1.—ELEVATION AND PLAN VIEW OF 200-H.P. DOUBLE-ACTING TANDEM GAS ENGINE.

Several methods of gas engine design have been followed in building a single structure to give large powers, among which may be mentioned the double-cylinder construction with a cylinder at each end of a common piston-rod, the use of one cylinder worked on the two-stroke cycle, and the use of two double-acting cylinders with four-stroke cycle operation at each end of each cylinder, the two cylinders being mounted in tandem. The latter is the method that has been most recently adopted by the Nuremberg builders, and accordinging to all reports this method will be followed by the Allis-Chalmers Company.

The designs of the Augsberg & Nuremberg Machine Company show a tendency toward the use in gas engine construction of all available features which have proved satisfactory in steam engine design. The double-acting tandem engines are provided with tail-rods and guides and a piston-rod guide between the two cylinders, so that the pistons are not supported by the cylinder walls, the entire weight being carried by the piston-rods and tail-rod. The bed frame, as may be seen from Fig. 1, is also in conformity with recognized good practice in steam engine construction. It has a continuous bearing on the foundation throughout its entire length, and is practically a single massive structure from the main bearings to the end of the tail-rod.

The type of valve and valve-gear used on the Nuremberg engine may be ascertained by reference to Fig. 3, which illustrates the valves and gear of a single-cylinder single-acting engine. As this engraving shows, the valves are spring seated and open positively by means of cams on a secondary shaft, which actuate the valves through rocker-arms and links; the exhaust-valve gear also includes wiper cams of a type similar to that used on marine engines of the walking-beam type. As this engraving shows, there are two inlet and two exhaust valves. The chief object of this arrangement is to reduce the work of operating the valves, one valve of a pair being made to open slightly in advance of the other; this, of course, reduces by nearly one-half the pressure to be overcome in opening the pair of valves, since there is

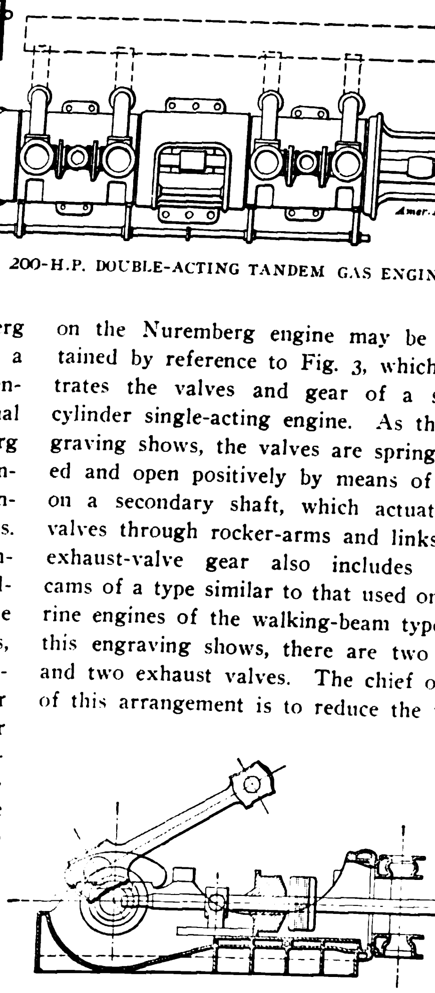


FIG. 2.

only the opposition of friction and the seating springs to be overcome in opening the second valve of each pair, the pressure having been equalized when the first valve was started.

There is also a mixing valve which is shown directly over the cylinder in Fig. 3, and which delivers the charge, mixed ready for admission, to the main inlet valves.

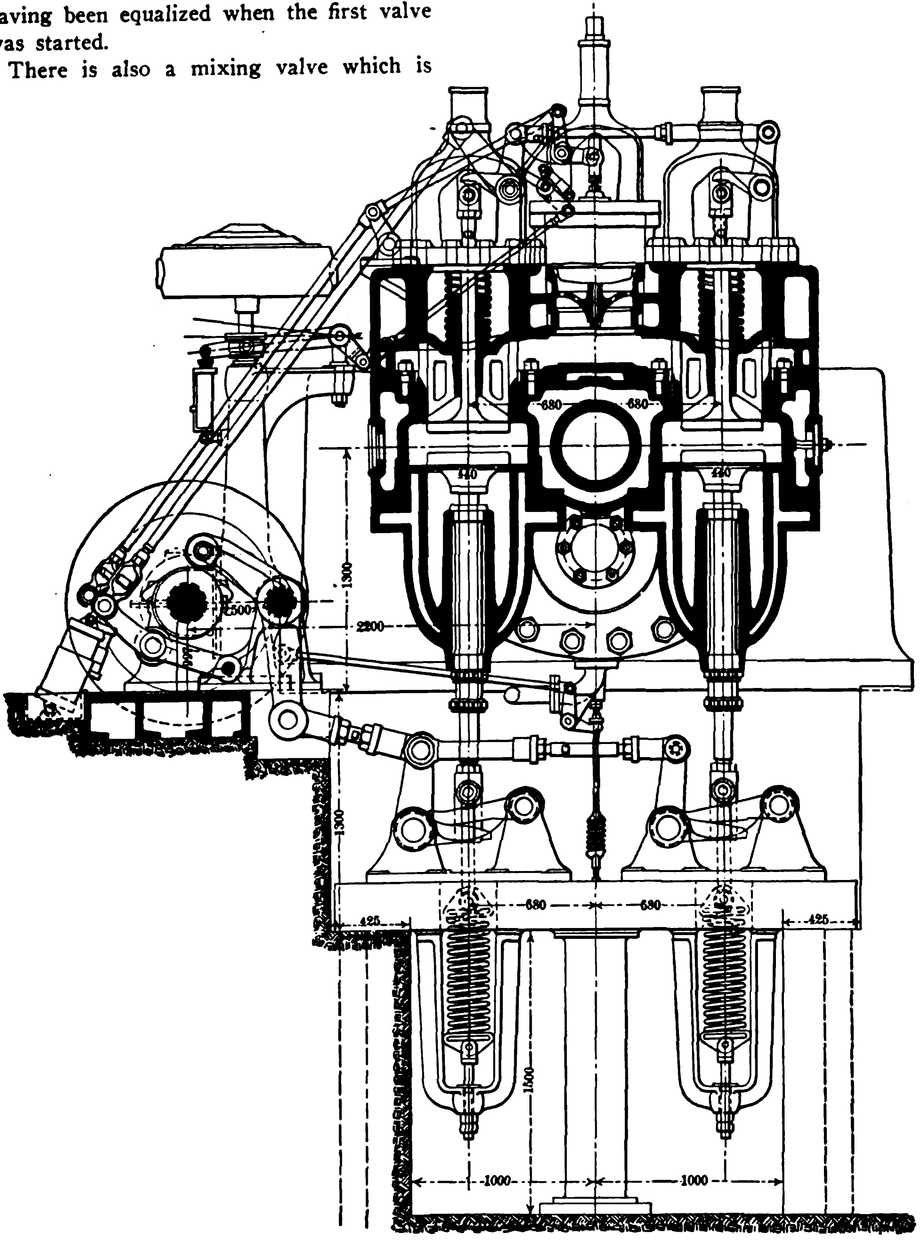


FIG. 3.—VALVE GEAR OF 750-HORSE-POWER SINGLE-CYLINDER GAS ENGINE.

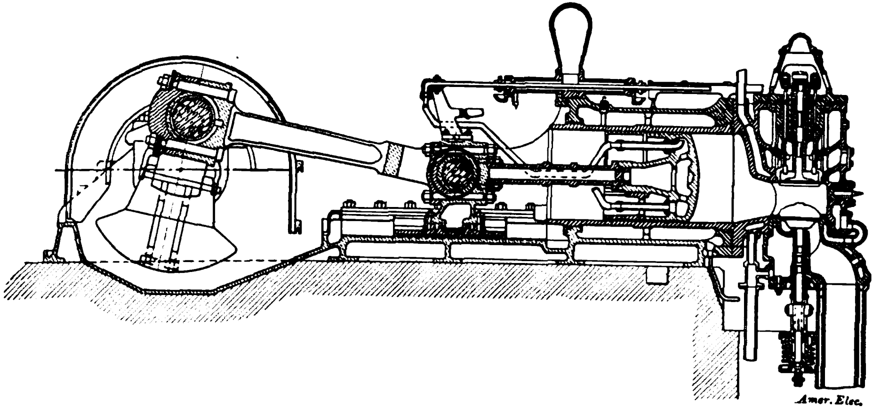


FIG. 4.—LONGITUDINAL CROSS-SECTION OF GAS ENGINE.

The cam motion is such that the admission valves are opened and closed very rapidly, remaining open during almost the entire admission period. The closing of the mixing valve is determined by the governor and is varied according to the requirements of the load; when working under light loads, the mixing valve closes considerably in advance of the main inlet valves, so that the mixture expands within the valve chambers during the remainder of the suction stroke. This, of course, affects the compression on the return stroke, and is one of the features of the engine, the governing being accomplished by varying the quantity of the mixture and the compression instead of varying the quality of the mixture or the frequency of explosions. This has the advantage, of course, that under light loads the pressure and temperature of compression are lower than under heavy loads, so that the maximum temperatures are also lower and the heat losses correspondingly less than would be the case with intermittent admission.

For ordinary examination of the interior of the cylinders, covered openings similar to the hand-holes of a steam boiler are provided; but in order to clean the cylinder thoroughly the covers are unbolted and pushed along the piston-rod, the connecting-rod being unshipped at the cross-head, as indicated in Fig. 2. The cylinders are made of cast steel and equipped with cast-iron liners with 1-in. walls, the liners being fitted into the cylinders while hot. The pistons and piston-rods are water-cooled, being made hollow, of course, for this purpose.

Lubricating oil is delivered under a pressure of about two pounds per square inch, and after use is cooled and purified to be used over again. This forced lubrication is applied to the main and crank-pin bearings, but the bearings of the secondary shafts are provided with oil rings and the eccentrics are lubricated with grease. All of the gears run in oil.

◆

CAST GRID RHEOSTATS.

An improved form of rheostat has been placed on the market by the Stanley Electric Manufacturing Company, Pittsfield, Mass., which differs from others in that the units are not connected to the studs by wires. The rheostat consists of 50 or 60 iron grids radially arranged. This arrangement results in a simple and compact mechanical construction. Each unit, as shown in Fig. 1 is formed with a projection extending at such an angle from the plane of the unit proper as to permit of direct connection with the next unit. A contact stud passes through two adjoining units, furnishing electrical connection between them and supporting them in place, at the same time supplying contact surface for the contact arm. Each unit is thus firmly fastened by two studs or bolts to the slate slab through which the studs pass. A corresponding slab on the further side provides additional support to the units, resulting in a rigid outfit which is mounted in a substantial and well-ventilated iron case. The units are cast of such shape as to furnish good radiating surface. The contact arm, is unusually broad, giving a good contact surface and permitting of the ready dissipation of heat.

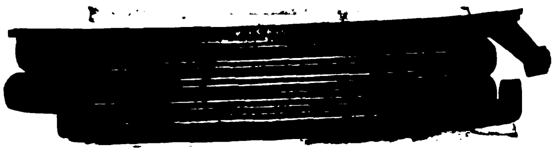


FIG. 1.—RESISTANCE UNIT.

New Apparatus and Appliances

GLASS-ENCLOSED WATTMETER.

Figs. 1 and 2 herewith show a form of magnetic suspension meter designed by the Stanley Instrument Company, of Great Barrington, Mass., for switchboard service. As shown in the illustrations, all the parts of the meter are enclosed by a glass cover, which is mounted upon an iron back or base plate, rendering every detail of construction visible. The parts are said to be highly finished, and all connections are made through the iron back plate and thence through the switchboard, no wires or connections appearing in front. The cover is so attached to the iron back plate that it is dust, insect and moisture-proof. The meter is ready for connection to the circuit when received, being calibrated and thoroughly tested before shipment. Hence, when properly connected in circuit, it will thereafter require no cleaning, readjustment or recalibration, and it is claimed will record accurately all the energy passed over the circuit with which it is connected. The meters can be furnished of any desired capacity, for either primary or secondary service, for any potential, and for use upon circuits of any frequency. It is manifest that as the magnetic suspension rotating parts do not touch any metallic or mineral parts, but simply float in the air without mechanical contact, there is neither friction nor wear, and this flotation in the air, it is claimed, causes the meter to register with its original accuracy throughout many years.

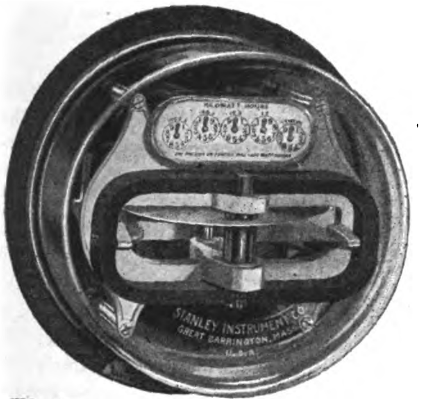


FIG. 1.—GLASS-ENCLOSED WATTMETER.

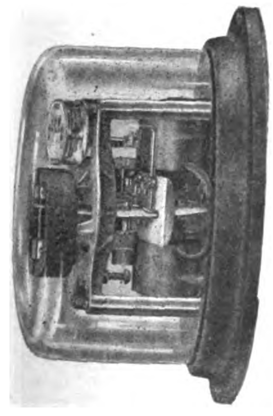


FIG. 2.—GLASS-ENCLOSED WATTMETER.

AUTOMATIC FLASH SIGN LAMPS.

The Phelps Company, of Detroit, Mich., has brought out a most ingenious and entirely new form of sign lamp, which embodies the "baby" filament feature of the company's well-known Hylo standard lamp for general service, there being one large and one small filament. The unique feature of the lamp consists of an automatic arrangement within the cap, which puts the two filaments alternately in circuit, the large filament being kept in circuit about one-third as long as the baby filament is burned. The baby filament is usually of one candle-power, and this is said not only to be sufficient to outline the usual type of sign letter, but to make it even easier to read a sign than is the case when high candle-power lamps are used. The 16-c.p. filament is thrown into circuit momentarily at short intervals merely for the purpose of attracting attention, which result it can scarcely fail to achieve. As will doubtless be understood from the foregoing statements, each lamp is entirely independent of all other lamps on the sign, so far as the alternate burning of the filaments is concerned. Since the baby filament remains in circuit most of the time, the expense for current is obviously much less than would be the case with a sign equipped with the ordinary 16-c.p. lamp. The baby filament can be made of 1, 4, 6 or 8 candle-power, but the preference would ordinarily be for the 1-c.p. filament, since this is adequate for illuminating the sign and requires only 9 watts for its operation. The manufacturers state that these lamps will burn 4000 hours. Besides sign illumination, the lamp is obviously well adapted for lighting show windows, show cases and other display points to which it is desired to attract the attention of passers-by.

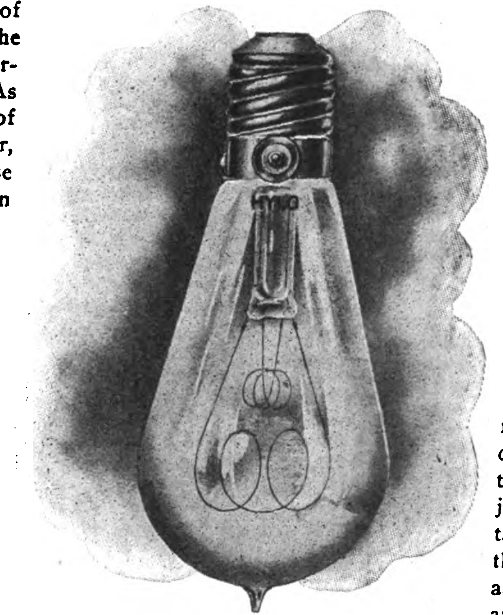


FIG. 3.—HYLO FLASH SIGN LAMP.

PORTABLE MOTOR-DRIVEN AIR COMPRESSORS.

The John Stevenson Company, of Elizabeth, N. J., recently made several additions to its shop equipment, among which may be noted an interesting self-contained air compressor mounted on wheels as illustrated by Fig. 4 herewith. This apparatus was built by N. A. Christensen, of Milwaukee, and is known as Type H. As the engraving clearly shows, the outfit consists of a combined motor and compressor, together with two storage tanks and a governor. The compressor has a piston displacement of 50 cubic feet of free air per minute, and the weight of the complete equipment is only 1625 pounds. The compressor is built for intermittent service, being intended to run approximately one-third of the time; on this account it is not water-jacketed, but the same class of outfit is built with water-jackets for continuous operation. The details of the compressor construction and the governor are of the same general type as used in connection with the Christensen air brakes on electric cars. When the outfit is to be used in dusty places, a cover is provided, which completely encloses the motor and governor, and is fitted with doors which permit inspection and adjustment without removing the cover. These outfits have proved extremely convenient and economical in shops requiring the application of compressed air at various points which may not always be fixed, and they have the advantage of eliminating the long lengths of flexible air hose which would be necessary if pipe lines were provided throughout the shops, no matter how extensive the stationary piping might be.

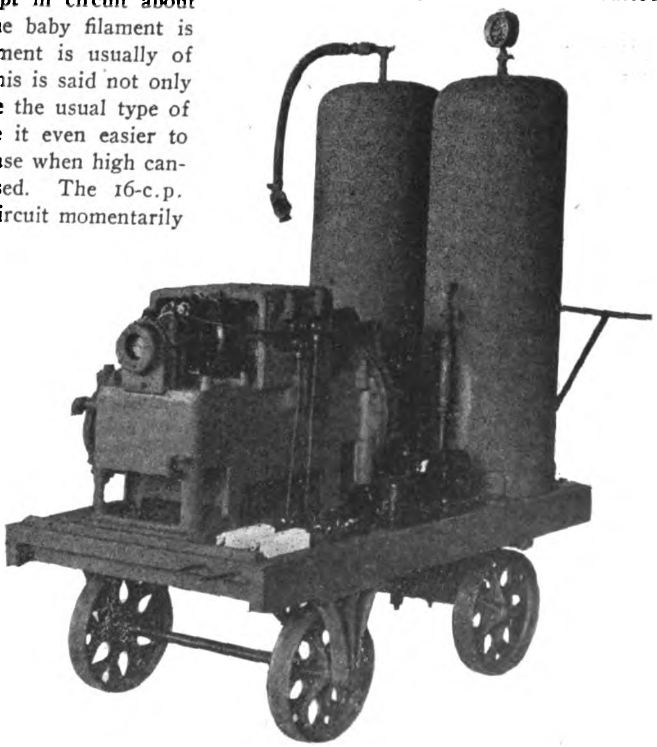


FIG. 4.—PORTABLE MOTOR-DRIVEN COMPRESSOR.

A NEW TELEPHONE RECEIVER.

The Holtzer-Cabot Electric Company, of Boston, Mass., is placing upon the market its new telephone receiver, shown in Figs. 5 and 6. The shell is made in two parts, i. e., the body of the shell and the cap. Following the latest practice, binding posts have been discarded. The terminals are entirely enclosed inside the shell, doing away with the danger of the user receiving a shock, while the cord, which is in all cases supplied with the receiver, is given a substantial hitch about the yoke of the magnet in such a way that no strain can come on the connections. Fig. 5 shows the internal arrangement of the parts. The permanent magnets are of a special grade of magnet steel, while the pole pieces are of soft Norway iron. It will be observed that the construction is bi-polar. The pole pieces being semi-circular in section, give an efficient distribution of the magnetic lines. This point is well brought out in Figs. 7 and 8. These diagrams were made by covering thin diaphragms with iron filings and holding them over the poles of the magnets. By gently tapping the diaphragm the iron filings were caused to arrange themselves in positions showing the direction and intensity of the magnetic lines in the region of the pole pieces. Fig. 7 shows the arrangement of the distribution in a field in which the pole pieces are rectangular and Fig. 8 in which they are semi-circular. The adjustment feature has been omitted entirely and the receivers are permanently adjusted before leaving the factory. The magnets are wound with silk-covered magnet wire, and corrosion is prevented by nickel-plating all exposed parts. In connection with the unusually strong magnet a heavy diaphragm is used, making a sensitive instrument, and one that will respond through a wide range of conditions of transmission. These instruments are carefully standardized and are made with tools, jigs, etc., so that all parts are interchangeable. The receiver may be supplied with either pure hard rubber or composition shell and the cord may be furnished with either silk or worsted covering.

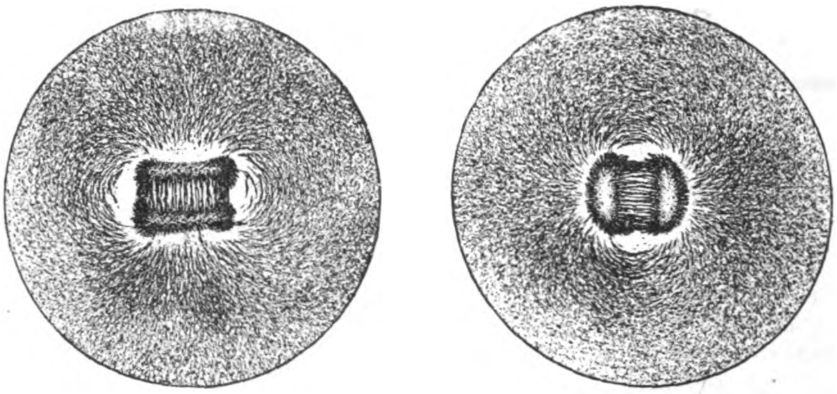


FIG. 7.—DISTRIBUTION OF MAGNETIC LINES.—FIG. 8.

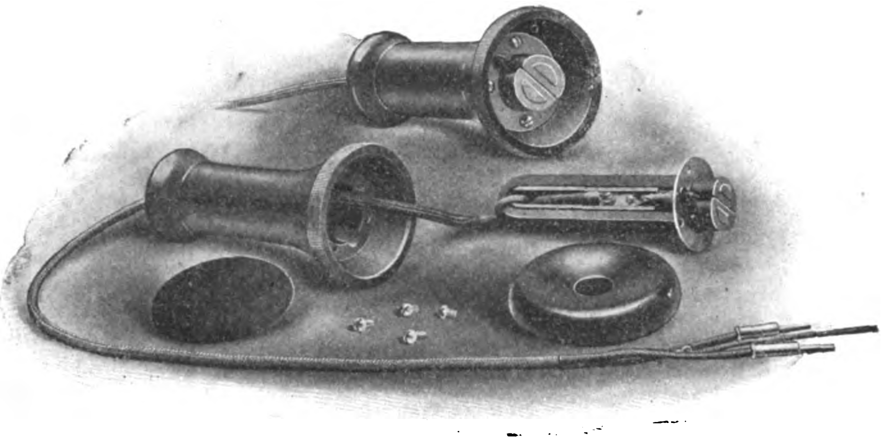


FIG. 5.—DISMANTLED TELEPHONE RECEIVER.

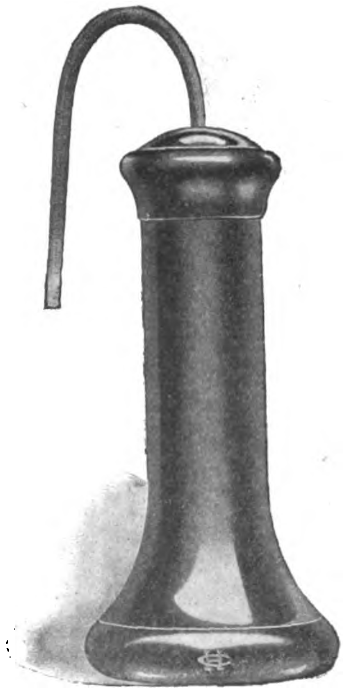


FIG. 6.—TELEPHONE RECEIVER.

HORIZONTAL QUINTUPLE PUMP.

The Aldrich horizontal quintuple pump, built by the Allentown Rolling Mills, Allentown, Pa., and illustrated by Fig. 9, by reason of the large number of cylinders delivers its discharge in an extremely uniform stream at a velocity not exceeding three feet per second. The pump has five single-acting plungers operated from one crank-shaft, the cranks being set 72 degrees apart angularly. The working load being divided among five plungers, the liability of breaking pump chambers, gears, cranks, etc., is obviously much less than if the work were done with two or three plungers. Furthermore, the builders point out the working barrels and valve chambers subjected to the working pressure are smaller, and therefore relatively stronger than would be the case with few cylinders. The motor is set in the center of a massive base, bolted to the pump housings, and the shafts are extended on each side and take the pinions and outboard bearings. The power from the motor is transmitted to the crank shaft by two gears and pinions, each of which is said to be strong enough to do the entire work. The crank-shaft is made from open-hearth cast steel, having a ten-

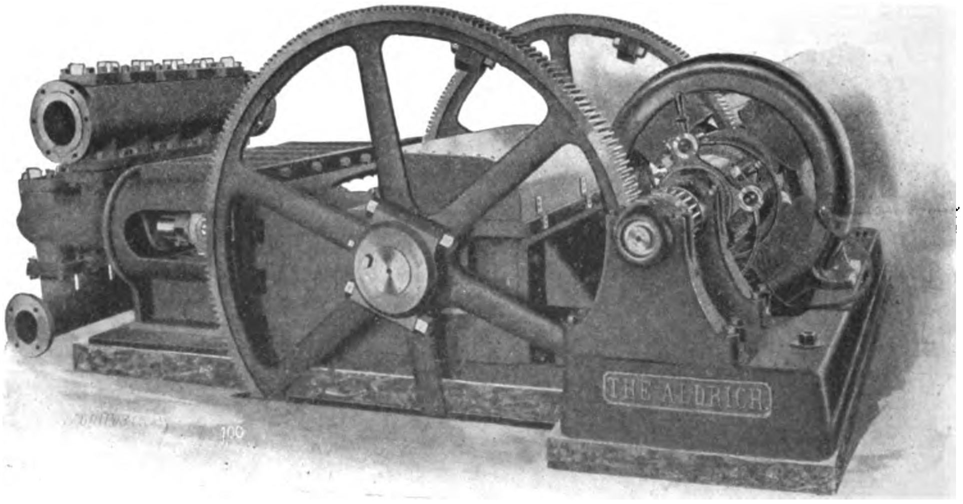


FIG. 9.—HORIZONTAL QUINTUPLE PUMP.

sile strength of 60,000 pounds per square inch, and of such size as to give a total strength of fifteen times the maximum load. The connecting rods are fitted with bronze adjustable bearings at each end, and the length of the rods is four times the length of stroke, which reduces the angularity and consequently the pressure upon the guides, below that usually obtained. The main journal box is made in three parts, giving side and top adjustment. The plungers are cast on end, and ground perfectly straight and cylindrical. The working barrels are separate castings, and contain the bronze valve seats which are readily accessible through covers held in position by hinge bolts. The valves are leather faced, with a bronze backing, and the water area is said to be such as to reduce the velocity of flow to less than three feet per second. In order to make the pump as nearly automatic as possible, the housings are cast with an oil case, and this is partly filled with oil, into which the connecting rods dip at each revolution. There is also attached a small rotary oil pump, which forces the oil from the oil case to each of the bearings, whence it drains back again, thus keeping up a continuous oiling process.

WIRELESS TELEGRAPH OUTFIT.

The accompanying engraving illustrates the "Class C, Junior," type of wireless telegraph outfit manufactured by the Thomas E. Clark Wireless Telegraph-Telephone Company, Detroit, Mich. As the engraving shows, the outfit is very compactly put up. The case shown on the left of the engraving contains the choke coils, condensers, adjustable resistance and tapper within the box, while two adjustable and interchangeable coherers are mounted on the surface of the horizontal partition, together with the platinum contact points, plug sockets, switches, and key for making silent tests. The transmitting key is shown directly in front of the induction coil. The latter is provided with adjustable spark-gap balls and the usual vibrating interrupter. The outfit is handsomely finished, all of the metal parts being heavily nickel-plated and polished, while the handles of the transmitting key, spark-gap adjusters, connecting plugs and switches are all of polished hard rubber. Two forms of telephone receiver are supplied, as the engraving indicates. It is stated that the induction coil, which is of the high-frequency variety, has given service over a distance of five miles satisfactorily.

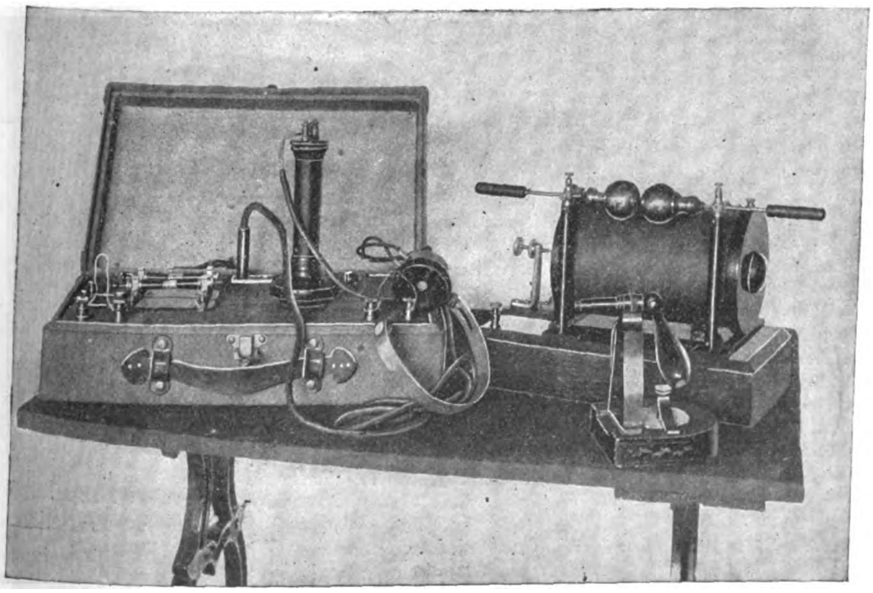
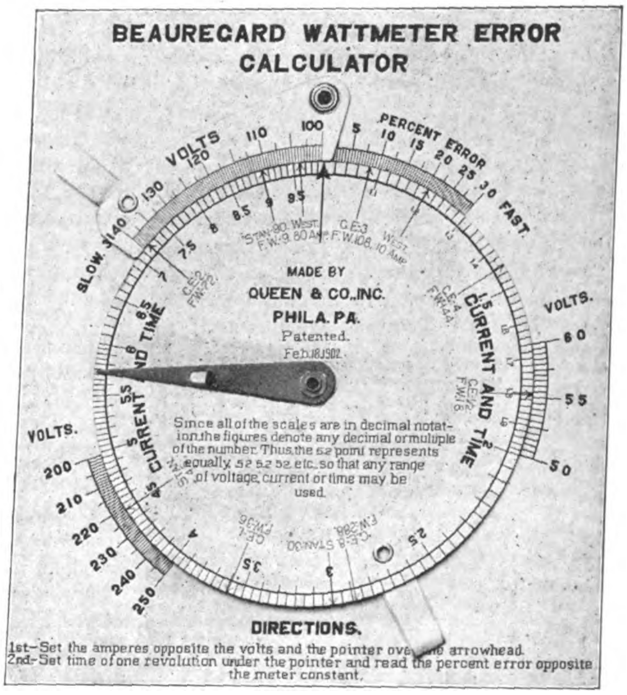


FIG. 10.—WIRELESS TELEGRAPH OUTFIT.

CALCULATOR FOR TESTING WATTMETERS.

The accompanying illustration shows a new form of mechanical calculator that has been brought out by Queen & Co., Philadelphia, for use in testing wattmeters. A combination of scales indicating voltage, current and time, are so arranged that when properly manipulated, an arrow-head indicates the percentage of error of the wattmeter under test, and a long and tedious calculation is thereby avoided. Only three movements of the parts are necessary to compute the error of a meter, and the calculator is applicable to the testing of every form and size of recording wattmeter, excepting chemical meters. It is claimed by the manufacturers that the time required to test a wattmeter with the aid of this calculator is just one-half of that required when no calculator is used, and that it can be operated to give accurate results by anyone who can read a meter dial. The directions for setting the calculator so as to read the per cent. of error directly is printed at the bottom of the scale card as shown in Fig. 11.



BEAUREGARD WATTMETER ERROR CALCULATOR

MADE BY
QUEEN & CO., INC.
PHILA. PA.
Patented.
Feb. 18, 1902.

Since all of the scales are in decimal notation, the figures denote any decimal or multiple of the number. Thus, the 52 point represents equally .52 5.2 52 etc., so that any range of voltage, current or time may be used.

DIRECTIONS.
1st—Set the amperes opposite the volts and the pointer over the arrowhead.
2nd—Set time of one revolution under the pointer and read the percent error opposite the meter constant.

FIG. 11.—CALCULATOR FOR TESTING WATTMETERS.

THE HOPPES OIL ELIMINATOR.

The accompanying illustration shows an oil eliminator especially designed with reference to the high velocity of exhaust steam in its passage from the engine to condenser and having in view the desirability of obstructing the flow of steam as little as possible. The machine illustrated is said to possess no working parts less than one and one-half times the area of the pipes, and no baffle plates or other serious obstructions to the flow of the steam. The design of the machine is such that the steam may flow through it in either direction, the separation of oil or grease being effected by means of troughs partially filled with water, which entirely surround the inlet and outlet ports. These troughs, it is claimed, intercept the entrainment on the surface and prevent it being sprayed into the steam chamber, and the downward plunge of the steam carries all suspended oil and water to the bottom, where it strikes the surface of the water and is retained. The oil is prevented from passing out of the bottom of the eliminator by the trough surrounding the outlet, which intercepts and returns any oil which may start to creep out on that side. Pipes

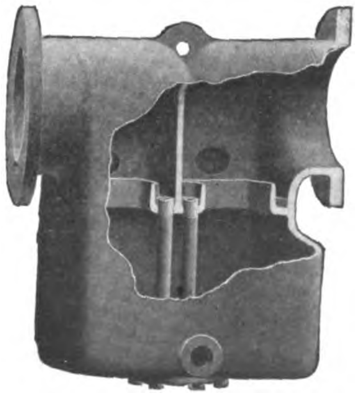


FIG. 12.—OIL ELIMINATOR.

are provided for draining the excess of oil and water from troughs to the lower chamber, from which it is drawn off by means of a trap or receiver in the usual manner. The machine is made in one casting, with pipe flanges, as shown in the engraving, and is also made so that the companion flanges may be bolted directly to the body. The manufacture of the eliminator is the Hoppes Manufacturing Company, of Springfield, Ohio.

NON-CARBONIZING SPARK PLUG.

Fig. 13 herewith is a sectional view of a new spark plug brought out by William Roche, of New York City. The construction of the plug, as may be seen from the engraving, is very simple. A porcelain tube surrounds an electrode capped at one end and provided with a binding post at the other; while around the tube is a brass sleeve, which forms the other terminal. The porcelain and sleeve are so shaped that a chamber is provided which not only protects the porcelain from breakage when the engine is cooling, but also causes the spark to jump across from the sleeve to the cap at different places on the circumference, so that the spark does not confine itself to one spot. The maker claims that no soot can deposit around the electrode on account of this chamber at the inner end. Every part is removable, and the plug is said to operate in oil.

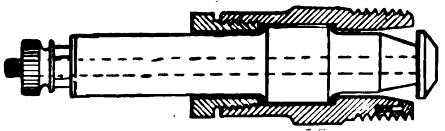


FIG. 13.—SPARK PLUG.

NEW BOOKS.

The How and Why of Electricity. By Charles Tripler Child. New York: Electrical Review Publishing Company. Cloth, 127 pages, 5 x 7½ inches, 40 illustrations. Price $1.00.

This little book is intended for non-technical readers who desire to know something about the properties of electricity and wish to understand the operation of some of the ordinary forms of electrical apparatus. The explanations are surprisingly simple, considering the complex nature of both the phenomena of electricity and the performance of most electrical devices. In addition to the general treatment of electricity and magnetism, chapters are devoted to the telephone and telegraph, dynamos and motors, alternating-current machines, lamps, electrochemistry, batteries, wireless telegraphy, and Roentgen rays.

Electric and Magnetic Calculations. By A. A. Atkinson. New York: D. Van Nostrand Company. Cloth; 310 pages, 5 ins. x 7⅜ ins.; 45 diagrams and 14 tables. Price, $1.50.

This is a collection of rules and formulas covering the simpler problems of electrical engineering. The book is arranged so that it can be used either as an introduction to a course in electrical engineering or as a reference book for those engaged in electrical practice. The illustrative problems, which are given throughout, are well chosen, and the solutions and explanations, simple and easily understood. It is to be regretted, however, that in the magnetic circuit calculations the old method on the basis of reluctances is given instead of the one now in general use of ampere-turns per unit of length of path. The first two chapters are devoted to electrical units and their relations to each other; in the succeeding chapters resistance, electrical energy, alternating currents, wiring, batteries and magnetic quantities are treated and the last three apply to dynamo and motor calculation and design.

THE ALLIS-CHALMERS ANNUAL REPORT.

The report of the Allis-Chalmers Co. for the fiscal year ending April 30, has just been issued, and must be a gratifying document to the stockholders of that enterprising company. The demand for the products of the concern during the year largely exceeded the capacity of the shops, notwithstanding increased facilities, and the unfilled orders on the books on May 1 were sufficient to keep the present shops going for a year. This certainly does not betoken an immediate diminution in industrial prosperity, although it has, of course, no bearing whatever upon the industrial trend next winter and thereafter. All the officials, committees and superintendents were re-elected, and J. Stillman and C. Allis were added to the Finance Committee.

National Electric Light Convention Notes.

McRoy Clay Works sent E. F. Kirkpatrick to the Convention.

Okonite interests were looked after by George T. Manson, of New York.

H. B. Ramey represented the Peerless Electric Company, of Warren, Ohio.

Chase Shawmut Company, of Boston, sent H. P. Moore to look after its interests.

Reynolds Electric Flasher Company, of Chicago, was represented by C. F. Ziegler.

Stanley Instrument Company. Great Barrington, Mass., sent S. O. Ochs and F. J. Alderson.

The Ewing-Merkle Electric Company, of St. Louis, was represented by M. W. Ewing and M. Mill.

American Steel & Wire Company were represented by Messrs. C. S. Knight, Jr., and F. A. Keyes.

Westinghouse, Church, Kerr & Co. sent Mr. E. Yawger, of Pittsburg, to look after their interests.

The Chicago Insulated Wire Company was ably represented by W. M. Smith and T. C. Turlay.

Benjamin Electric Manufacturing Company, Chicago, exhibited a line of Benjamin wireless clusters.

Mr. W. Sharpe, of Chicago, represented the Ridgway Dynamo & Engine Company, of Ridgway, Pa.

American District Steam Company, of Lockport, N. Y., was represented by J. C. Young and H. C. Eddy.

Mr. J. B. Olsen was sent to the Convention so that the Habirshaw wires and cables should not be forgotten.

The Triumph Electric Company, of Cincinnati, was represented as usual by W. J. Jacob, sales manager.

M. S. Walker, of the F. Bissell Company, of Toledo, Ohio, interested many of the delegates in the Nernst lamp.

Hart Manufacturing Company, of Hartford, Conn., had an attractive exhibit of its switches on the main floor.

M. B. Austin & Co., of Chicago, placed its interests in the hands of H. T. Tate, A. Mementa and A. H. Friend.

Sprague Electric Company sent Mr. A. Henderson, of its conduit department, and Mr. Kittle, of the Chcago office.

H. B. Kirkland, R. B. Corey and T. G. Grier were present in the interests of the American Circular Loom Company.

Northern Electrical Manufacturing Company, Madison, Wis., was represented by F. L. Stagg and H. Markel.

Messrs. E. L. Clark, F. L. McGillan and J. A. Greenwood represented the Valentine-Clark Company, of Chicago.

Rossiter, MacGovern Company, of New York, were ably represented by President MacGovern and Mr. J. A. Peirce.

The Western Electrical Supply Company, of St. Louis, sent as its representatives R. S. Wakefield and L. F. Philo.

Messrs. J. C. Shainwald and E. R. Willard looked after the welfare of the Standard Paint Company, of New York.

The Yost Electric Manufacturing Company, Toledo, Ohio, sent J. H. Yost and F. H. Chapman to the Convention.

The interests of the Otis Elevator Company were well taken care of by Messrs R. D. Lillibridge and J. D. Sheldon.

The Phoenix Glass Company had its interests well taken care of by Vice-president A. H. Patterson and T. H. Howard.

Mr. S. B. Condit, Jr., of Boston, was present at the Convention and explained the merits of his various electrical specialties.

The Consolidated Engine Stop Company, of New York, showed their various devices through their representative, F. S. Palmer.

E. Munsell & Co., of New York and Chicago, exhibited a fine specimen of sheet mica over the main stairway in the Auditorium.

The Dale Company, New York, had an interesting exhibit of its specialties in charge of Mr. J. Dale, president of the company.

Mr. M. Norden, of New York, looked after the interests of the Norden-Bittner Electric Company and the Electric Carriage Call Company.

The interests of the Buckeye Electric Company were looked after by W. K. Eyre, W. R. Bonham, A. J. Schrum and J. M. Corke.

Sawyer-Man Electric Company, whose lamps were in evidence in the Auditorium, were represented by T. H. B. Whipple and F. S. Smith.

Messrs. J. W. McDowell, F. M. Pierce and A. J. Anderson ably represented the Manhattan Electrical Supply Company, of New York City.

Mr. J. A. Seymour graced the Convention in the interests of McIntosh, Seymour & Co., of Auburn, N. Y., the well-known engine builders.

The Dearborn Drug & Chemical Works, of Chicago, distributed an amusing puzzle, and had an able representative in its president, W. H. Edgar.

Green Fuel Economizer Company, Matteawan, N. Y., was represented by W. H. Best of the Chicago office.

The Gregory Electric Company, of Chicago, were ably represented in the persons of A. L. Kuehmstedt, George M. Ellis and R. H. Watson.

The Varley Duplex Magnet Company, of Phillipsdale, R. I., sent C. A. Hibbard, of their Chicago office, to represent them at the convention.

Messrs. A. S. Hubbard, E. Lyndon, H. B. Oakman and E. L. Draffen were present on behalf of the Gould Storage Battery Company, of New York.

Mr. J. I. Ayre, past president of the association, was present in the interests of the Simplex Electric Heating Company, of which he is manager.

Milwaukee Electric Company, Milwaukee, Wis., was represented by W. Cary, T. H. Rodman, and several others from the engineering department.

President F. R. Bacon, A. P. Munning and W. H. Beattys, Jr., efficiently represented The Cutler-Hammer Manufacturing Company, of Milwaukee.

The Fostoria Incandescent Lamp Company, of Fostoria, Ohio, had for its representatives H. H. Geary, F. G. Kreatcher, J. S. Maurer and C. J. Wells.

Standard Vitrified Conduit Company was represented by Vice-president B. S. Barnard, who interested many of the delegates in the product of his company.

Mr. B. C. Kenyon represented the Diehl Manufacturing Company and displayed its new models in fan motors and reflectors in the lobby of the Auditorium.

General Incandescent Arc Light Company, of New York City, made an excellent display, and was ably represented by M. J. Insull, H. P. Ball and J. H. Hallberg.

H. G. **Osburn** and C. E. Corrigan, of the Osburn Flexible Conduit Company, of New York, went to the Convention to tell of the good qualities of "Flexduct."

The Shedd Electric Manufacturing Company, of New York, had several of their oscillating fans on the main floor, and was represented by Mr. R. J. Peterson.

Economical Electric Lamp Company, of New York, had a novel display of its "turn down" lamp on the first floor of the Auditorium, in charge of M. Lobenthal.

The Moloney Electric Company, of St. Louis, Mo., was ably represented by Mr. T. O. Moloney, who interested many of the delegates in the merits of his transformers.

Pass & Seymour's well-known insulators were shown and described by B. E. Salisbury, from the factory at Solvay, N. Y., and J. W. Brooks, their Chicago representative.

The Nernst Lamp Company was represented at the convention by Messrs. A. E. Flemin, G. E. Bennett, F. H. Carpenter, C. W. Rice, R. H. Lee, Jr., and M. W. Hanks.

J. S. **Maurer** looked after the interests of Hart & Co., of Chicago, and the Marshall Sanders Company, of Boston. He was assisted in displaying the Hart goods by E. Kearns.

Mr. G. F. Porter, ex-secretary of the association, was warmly welcomed at the Convention. He represented the Atlantic Insulated Wire & Cable Company, of New York.

Standard Underground Cable Company had a corps of representatives including C. J. Marsh, J. R. Wiley, E. J. Pietzcker, W. M. Rogers, T. E. Hughes and A. A. Anderson.

Mr. A. R. Batley was present in the interests of the Pittsburg Sewer Pipe & Conduit Company, of Pittsburg, Kan., who made a neat exhibit of two and four-duct conduit, etc.

The interests of John A. Roebling's Sons Company were well looked after by F. W. Harrington, D. F. Ivins, G. C. Bailey, W. H. Slingluff, A. B. Conover and E. P. Bartlett.

Alphaduct Manufacturing Company, of New York, was ably represented by its Western sales manager, W. H. Porter, and distributed pipes made from their fire-proof conduit.

The Electric Storage Battery Company sent Messrs. Charles Blizard, G. H. Atkin, Otto E. Osthoff, G. W. Hill, H. B. Gay and R. H. Klauder to represent them at the Convention

Messrs. William Coale and G. S. Sayles, representing the Sterling Electric Manufacturing Company, of Warren, Ohio, made quite a showing of the Sterling Special incandescent lamp.

The Jewell Electrical Instrument Company, of Chicago, had an interesting exhibit, E. W. Jewell and W. H. Huson being in attendance to explain the features of the Jewell meters.

Bryan-Marsh Company, the well-known incandescent lamp manufacturers, sent G. C. Keech, L. D. Sawyer, E. H. Haughton, J. L. Barnard, A. G. Bowers, J. S. Corby and W. G. Behn.

The New York & Ohio Company, of Warren, Ohio, had an interesting exhibit of its new insulating material, as well as Packard lamps and tansformers, in charge of Mr. W. D. Packard.

Mr. C. O. Baker, Jr., the popular and genial master of transportation for the association, and Mr. J. J. Lowthian represented Baker & Co., platinum refiners and dealers, of Newark, N. J.

Crocker-Wheeler Electric Company sent Messrs. P. A. Bates and C. W. Startsman from the Ampere (N. J.) works, Mr. J. Roe, of Chicago, and Mr. F. G. Whipple to look after its interests.

Holophane Glass Company, of New York, made an interesting exhibit and distributed handsome souvenirs. Mr. Van Rensselaer Lansingh and Mr. H. W. Lauritzen were present to look after the exhibits.

Federal Electric Company, of Chicago, exhibited a full line of its electric signs and J. M. Gilchrist, assisted by M. D. MacKenzie, was on hand to demonstrate the advantages of the porcelain-enamel metal feature.

The Monarch Electric & Wire Company, of Chicago, made an exhibit of their water-proof wire and general supplies. C. A. Kuhlman, A. D. Gillespie and H. Schwab were in attendance as representatives of the company.

American Push Button Telephone Company, of New York City, had a unique display of a complete telephone outfit connected to 200 feet of wire, which is all contained in a small grip. W. B. Sweeton represented the company.

The Standard Electrical Manufacturing Company, of Niles, Ohio, exhibited a line of candelabra and decorative lamps. Messrs. J. P. Gilbert, secretary and treasurer, and H. H. Albert and John Rice represented the company.

The Banner Electric Company, of Youngstown, Ohio, exhibited a line of its incandescent lamps. The exhibit was in charge of Secretary N. L. Norris and F. C. Kirchner assisted by R. T. Hamilton, J. E. Hart and E. N. Beach.

The Fort Wayne Electric Company exhibited their new revolving fan motor. It was represented by Sales Manager F. S. Hunting, W. S. Goll, T. J. Ryan, W. C. Knight, J. H. Raymond, F. McMaster, I. S. Jackson, A. A. Serva and E. A. Wagner.

Stanley Electric Manufacturing Company had a handsome suite of rooms, and was ably represented by Messrs. R. D. Lillibridge, E. L. Barr, V. W. Bergenthal, L. Etheridge, D. W. Dunn, M. C. Canfield, J. W. Chambers and G. W. Andress.

The Columbia Incandescent Lamp Company, of St. Louis, Mo., had its interests well looked after by Mr. R. B. Corey, of the New York office. Many inquiries were heard for the company's genial president, Mr. O. W. Garrison, who was unable to be present.

G. M. **Gest**, of Cincinnati, the electrical subway contractor, whose "manhole," exhibit at the Cincinnati Convention last year attracted so much favorable attention, had an interesting exhibit in the Auditorium Annex in charge of Messrs. F. C. Mott and W. T. Jackson.

National Electric Company was represented by F. L. Hutchinson, C. G. Burton, A. Jones, W. L. Waters and C. D. Knight. As announced in the June number of the **American Electrician**, this company is successor to the Christensen Engineering Company, of Milwaukee.

W. N. **Matthews & Bro.**, of St. Louis, were represented by F. A. Churchill, Jr., who showed a working exhibit of the firm's new steam scale knocker. Mr. Churchill also called the attention of the visitors to the merits of the Stombaugh guy anchors handled by his company.

The National Carbon Company, Cleveland, Ohio, as usual sent a large delegation to the Convention, consisting of N. C. Cotabish, A. W. Wilkins, A. D. Spear, F. H. Murray, F. C. Park, T. H. McDowell, F. J. Aylsela, A. V. Ward, A. G. Henry, A. C. Carrier and W. O'Connor.

The Central Electric Company, of Chicago, had a large delegation constantly mingling with the Convention delegates. Manager Charles E. Brown was frequently in attendance and contributed much to the enjoyment of the many patrons of his company who attended the Convention.

The Wagner Electric Company, of St. Louis, exhibited a 1-h.p. and a 4-h.p. single-phase self-starting motor, a 3-kw. Type F ammeter, and a new vertical edgewise illuminated dial switchboard voltmeter; and had its interests well taken care of by Messrs. R. J. Russell and G. E. Foster.

The Elblight Company of America decorated the South Parlor with Elblight cable and miniature lights of many colors, and also exhibited an aquarium with Elblight cable and a lamp burning under water. The company was represented by Messrs. R. Spaulding, E. H. Abadie and J. A. Haines.

The Phelps Company, Detroit, Mich., had a flash sign of Hylo lamps in the main lobby, which attracted much attention. W. E. Phelps, W. J. Phelps and J. W. Phelps were in attendance at the Convention and explained the interesting features of the various makes of Hylo lamps manufactured by this company.

The Duncan Electric Manufacturing Company, of Lafayette, Ind., was represented by T. Duncan and C. H. Norwoods. A very complete display of the Duncan wattmeter was made in one of the parlors. Mr. W. J. Flannery, of the Electrical Material Company, Baltimore, agents for the Duncan apparatus, was also present.

H. W. **Johns-Manville Company**, of New York, had a very elaborate and interesting exhibit of its well-known Sachs "Noark" enclosed fuse protective devices, and distributed a catalogue of their devices. A number of other specialties of the company's manufacture was also exhibited. J. W. Perry and S. H. Finney were in attendance.

The merits of the Martin anti-friction rocking grate were demonstrated by G. W. Tracy, of the Martin Grate Company, of Chicago. This grate is fitted to burn any kind of coal, but is said to be especially adapted for the slack and screenings of soft coals. Count Alexander Cavalli, a representative of the Martin Grate Company was in constant attendance.

The Crouse-Hinds Electric Company, of Syracuse, N. Y., made an interesting exhibit of its "Norbitt" and other specialties, and distributed small pocket mirrors encased in leather as souvenirs. Mr. Crouse came on from Syracuse, and with Mr. Hawkins, of the New York office, and Messrs. F. F. Skeel, R. B. Kent and F. E. Hardin represented the company.

The Bullock Electric Manufacturing Company, of Cincinnati, published four issues of the programme and register of delegates during the Convention. Charms were presented to visitors at their headquarters, as was the case in previous conventions, bearing a representation of a Bullock generator. Each delegate registering was also given a white button badge to correspond with his number in the Bullock bulletin. Robert T. Lozier, F. G. Bolles and G. B. Foster represented the company.

The General Electric Company occupied the large south parlor on the first floor of the Auditorium. Among the representatives of the company who attended the convention were J. R. Lovejoy, B. E. Sunny, C. B. Davis, A. F. Giles, J. S. Anthony, A. D. Page, C. D. Haskins, W. S. Moody, H. W. Hillman, P. D. Wagoner, J. C. Calisch, George D. Rosenthal, W. M. Deming and E. H. Mullin. During the week, Mr. W. L. R. Emmet, who has done such effective work on the Curtis steam turbine, arrived with Mr. Gilbert.

Electric Appliance Company, of Chicago, was represented by I. A. Bennett, W. P. Upham, P. R. Boole, S. A. Rall and others. The exhibit of the Electric Appliance Company was shown individually by the different companies which it represents. A full line of Guttman wattmeters was shown by the Sangamo Electric Company, of Springfield, Ill., the special merits of these meters being demonstrated by R. C. Lamphere. J. G. Pomeroy displayed the well-known line of incandescent lamps manufactured by the Adams-Bagnall Company, of Cleveland. The Crescent Company's exhibit was looked after by James McGill. President W. W. Low, of the Electric Appliance Company, was also in frequent attendance.

The Western Electric Company had a series arc light equipment in operation in the engine room of the Auditorium Annex. The local exhibit was in charge of Messrs. W. S. Hine and L. G. Basset. General Manager C. D. Crandall was in attendance, and had a full contingent from his various departments, representing the interests of the company. The apparatus department was represented by A. Tucker, W. L. Stockton, C. A. S. Howlett, H. B. Squire and C. W. Cobb. Messrs. C. E. Scribner, E. W. Rockefeller, P. T. Ackerson, S. Reed Faris, George Lounsberry, C. H. Talmadge and R. M. Field were in charge of the supply department. The Chicago supply department was represented by L. F. Milner, A. L. Brown, P. H. Aaron and William Devine. The engineering department was represented by C. Wiler, W. T. Hessel, of the Standard Electric Company, of Cincinnati, which is affiliated with the Western Electric Company, and the advertising department was represented by F. K. Kretschmar.

There were also present D. C. Hemingray, of the Hemingray Glass Company, of Covington, Ky.; W. R. Mason, general manager of the Mechanical Boiler Cleaner Company, of Chicago; E. A. Jenkins, of the H. T. Paiste Company, of Philadelphia and Chicago.; E. E. Woodward, of the Woodward Governor Company, of Rockford, Ill.; Enos Bookwalter, representing A. L. Ide & Sons, of Springfield, Ill.; V. G. Apple, of the Dayton (Ohio) Electric Manufacturing Company; J. B. Estabrook, of the Colonial Electric Company, Ravenna, Ohio; J. S. Crider, secretary of the Washington Carbon Company; G. G. Luthy, of the Royal Electric Company, of Peoria, Ill.; A. M. Searles, the Chicago representative of the Warren Electric Manufacturing Company; Charles Messer, president of the Dearborn Electric Company; W. C. Bryant, Bryant Electric Company, of Bridgeport, Conn.; J. A. Vaughan, Carleton-Chase Electric Company, of New York; R. Link, Keuffel & Esser Company; C. P. Hill, Doubleday-Hill Electric Company, of Pittsburgh; E. H. Noyes, Pittsburg Reduction Company; A. D. Wyckoff, Ball & Wood Company, of New York; W. F. S. Lake, Buffalo Forge Company; E. H. Hammond, American Electrical Works, of Providence, R. I., and O. P. Cone, Hawks Electric Company, Boston.

Westinghouse Electric Manufacturing Company occupied commodious quarters and utilized the electric plant of the Auditorium Hotel for exhibition purposes. The hotel has in use over 38,000 Sawyer-Man incandescent lamps which are supplied from a 500-kw. Westinghouse engine type direct-current generator. The generating room is located in the annex of the hotel and furnishes light and power for the two hotels and the theatre. A special panel board designed to show the operation of various types of Westinghouse precision instruments attracted considerable attention. These included the synchroscope, the power factor meter, various wattmeters and voltmeters and a frequency meter. Many of the staff of the company were in attendance, including F. H. Taylor, C. F. Scott, W. M. Probasco, E. W. T. Gray, A. L. Millard, E. J. Burke, A. E. Ransom, A. M. Miller, J. J. Gibson, P. S. Gibson, J. S. Peck, N. S. Braden, A. Hartwell, C. S. Cook, A. Huntington, R. E. Schanlin, R. N. C. Barnes, W. H. Whiteside, F. N. Kollock, R. L. Rathbone, S. H. Anderson, M. P. Randolph, S. B. Storer, W. D. McDonald, E. Dryer, N. Stewart, G. B. Dusenberre, H. P. Davis, W. C. Armstrong, W. Karapetoff, W. E. Foreman, T. P. Gaylord, G. W. Pulver, F. S. Smith, C. A. Ross, T. H. B. Whipple and H. C. Marsh.

Independent Telephone Convention Notes.

The Crawfordsville Wire Nail Company was represented by H. E. Cobb.

The Chicago Telephone Holder Company, was represented by F. W. Pardee.

The Central Electric Company, of Chicago, was represented by Mr. J. A. Mason.

The Allen-Hussey Company, Chicago, was represented by A. H. Hussey, president.

The National Telephone Supply Company, of Cleveland, was represented by Fred P. Auxer.

The Maltby Lumber Company, Bay City, Mich., was ably represented by I. A. Maltby.

Ohio Valley Glass Company were represented by Charles O. Hatch, their representative in Chicago.

Carney Brothers Company, Chicago, cedar poles were represented by W. J. Carney and T. J. Carney.

The Frank B. Cook Company, of Chicago, was represented by F. B. Cook, James A. Cook, and C. E. White.

The Varley Duplex Magnet Company, of Phillipsdale, R. I., was represented by Mr. C. L. Hibbard, of the Chicago office.

The Monarch Telephone Manufacturing Company, Chicago, was represented by Ernest E. Yoxley and Walter H. Trimm.

The Turner Brass Works, Chicago, had an attractive exhibit showing many kinds of metal appliances, in charge of Mr. Ferris.

The Eureka Electric Company, of Chicago, had an attractive exhibit looked after by Paul Gardner, C. L. Cammen and S. J. Kusel.

The Gordon Battery Company, New York, was represented by E. M. Deems, Chicago representative, and W. C. Banks, of New York.

The Chicago Telephone Supply Company had an interesting exhibit of telephones, which were in charge of E. A. Briggs and H. C. Randall.

National Carbon Company, of Cleveland, had its interests looked after by M. H. Moffett and A. B. Ward. This company had an attractive exhibit of dry cells.

The Stromberg-Carlson Telephone Company, of Chicago, manufacturers of the well-known Central-Energy System, was ably represented by Mr. F. L. Martin.

The Valentine-Clark Company, of Chicago, one of the largest pole concerns, was represented by Mr. E. W. Valentine, president, and E. L. Clark, secretary.

The New Haven Novelty Machine Company, of New Haven, Conn., was represented by H. J. Minhinnick, western representative, and Mr. H. Grant Thompson.

Baker & Company, New York, who now have a full line of rivets for electric contacts on telephone and electrical apparatus, were represented by J. J. Lothian.

The Illinois Electric Company, Chicago, was represented by H. B. Ranney, L. L. Litcher and C. W. Bacon. This firm showed an attractive display of specialties.

The F. Bissell Company, of Toledo, sent Messrs. W. S. Bissell and Mr. C. M. Hamilton to the convention to explain the merits of their telephone products to the delegates.

The Standard Underground Cable Company, of Pittsburgh, was represented by J. R. Wiley, western manager, W. M. Rogers, of Chicago, and F. S. Veile, of Pittsburgh.

Francis Beidler & Company, Chicago manufacturers of posts and poles, were represented by M. B. Cross and W. G. Ramshall. They made a strong feature of their Idaho cedar poles.

Lindsley Brothers Company, Chicago, cedar poles, was looked after by G. L. Lindsley, president; P. A. Lindsley, secretary and treasurer, and L. A. Navarre, assistant manager.

The Miller Anchor Company, of Norwalk, Ohio, exhibited the Miller anchor and auger used in anchoring guy wires. This anchor is designed for use in both earth and rock. Mr. G. H. Miller was in attendance.

The Sterling Electric Company, of Lafayette, Indiana, was ably represented by H. F. Doolittle, E. Shelby and F. E. Rotchka. They distributed very attractive souvenirs in the shape of a miniature desk telephone.

The Williams Abbott Electric Company, of Cleveland, distributed a very attractive souvenir in the shape of a full sized telephone transmitter. Mr. L. Sands, the president of the company, was in attendance at the convention.

The North Electric Company, of Cleveland, had a large electric sign directing attention to its exhibit, which was in charge of C. H. North, L. G. Bowman and F. F. Sapp. This concern showed large and attractive photographs of equipments.

The Clark Automatic Telephone Switchboard Company, of Providence, R. I., was represented by General Manager J. L. Putnam, whose indefatigable efforts have done so much toward placing the company in its present prosperous condition.

The American Electric Telephone Company, of Chicago, showed many of the delegates through their factory. Messrs. P. C. Burns, J. G. Ihmsen, and J. H. Reid, and other representatives were in constant attendance at the convention. Mr. Ihmsen was chairman of the local committee on arrangements.

The Swedish American Telephone Company's interests were looked after by Mr. E. P. Overshiner, Mr. A. V. Overshiner, Mr. C. H. Macklin, Mr. J. A. Russell and Mr. A. E. Dobbs. This firm ran automobiles from the Auditorium, where the Convention was held, to their factory at 90 W. Jackson Boulevard.

The Automatic Electric Company, of Chicago, took a large automobile party from the convention to inspect the tunnel and exchange being built for the Illinois Telephone & Telegraph Company. This exchange will be the largest automatic exchange ever attempted in this country. Messrs. J. F. Crook, H. D. Critchfield, Sanford Harris, J. C. Caldwell, F. H. Wheeler, and M. A. Edson were in frequent attendance at the convention.

The Thos. E. Clark Wireless Telegraph & Telephone Company, of Detroit, had a working exhibit which attracted as much attention as any at the convention. It consisted of their Class C Junior type apparatus for use from one to five miles, and also their standard No. 1 machine, adapted for distances of five to fifteen miles. This firm had two rooms and in one was located the sending apparatus while the receiving end was in another room. The doors were then shut and a message sent through the partition, giving a graphic display of wireless telegraphy. The company's interests were ably looked after by Mr. Hustave F. Riefsthal, secretary, and Ackland Stiling, advertising manager. The machines were operated by Fred F. Garrett.

OBITUARY.

G. F. BREITENSTEIN, superintendent of the Fire Telephone System of Utica, N. Y., died on June 2, from typhoid fever. Mr. Breitenstein was a prominent member of the International Association of Municipal Electricians.

MR. PAUL WERNER, a well-known inventor, died at his home in Hoboken, N. J., on June 14, from brain fever, which was said to have resulted from over work on a special type of electric motor which he had been trying to perfect. Mr. Werner originated the noiseless cable wheel which was used by the North Hudson County Railway when the elevated road between Hoboken and Jersey City Heights was a cable road.

PERSONAL.

MR. E. W. RICE, JR., vice-president and chief of the engineering department of the General Electric Company, has been elected a trustee of Union College, Schenectady.

MR. CHARLES DAY, of the firm of Dodge & Day, Philadelphia, recently read an interesting paper on machine shop methods, before the S. K. C. Club, at Pittsfield, Mass.

MR. W. T. JACKSON, representing G. M. Gest, the well-known conduit manufacturer, of Cincinnati, has been East for some time, and has closed some extremely good conduit contracts in this section.

MR. WILLIAM BURLINGHAM, formerly with the William R. Trigg Company, of Richmond, and previously with the Bath Iron Works, the General Electric Company, and other prominent manufacturing concerns, has been appointed chief engine designer for the B. F. Sturtevant Company, Boston, Mass.

MR. A. M. LITTLE has been appointed manager of the Boston office of Pass & Seymour, Inc., and will carry in stock at the Boston office a full line of P. & S. specialties. Mr. Little has for several months past represented the company as sales-agent in the factory territory, and his success in that territory has resulted in the present appointment.

MR. HENRY R. CORNELIUS, who was for many years the Pittsburg representative of the Southwark Foundry & Machine Company, Philadelphia, has severed his connection with that company in order to take charge of the business of the Brown-Corliss Engine Company in the Pittsburg territory. Mr. Cornelius has established offices in the Frick Building, Pittsburg.

MR. CLARENCE P. FOWLER, who has been connected with the New York staff of the Westinghouse Electric & Manufacturing Company for two years, was recently transferred to the Baltimore office, his services being required at that point in connection with several contracts which the company has in hand for large equipments in that locality.

MR. J. C. BROCKSMITH, a well-known engineer of Chicago, and a valued contributor to the reading columns of the AMERICAN ELECTRICIAN, has been granted a patent on storage battery grid construction, the chief features of which are the strengthening of the plates or grids and an increase in the output per unit of weight without affecting the durability of the plates.

MR. H. M. DAVIS, the well-known and universally popular advertising manager of the Sprague Electric Company, was married on June 3, to Miss Grace Inez Barrett, of Saratoga, N. Y. Mr. and Mrs. Davis have taken up their residence on the upper West Side in New York City. The AMERICAN ELECTRICIAN extends hearty congratulations to Mr. Davis, and best wishes for future happiness and prosperity to both his bride and his lucky self.

MR. J. M. DASHIELL, who formerly represented the Harrison Safety Boiler Works in New England, under the style of the Dashiell Engineering Company, with headquarters at Boston, has been transferred to Baltimore, and will have charge of the Harrison Company's business in that section. The New England office will be continued at 1103 Paddock Building, Boston, under the Harrison Safety Boiler Works name, and will be under the management of Mr. John Hickey.

MR. E. W. TRAFFORD, who for the past ten or twelve years has had charge of practically all of the electric lighting and power interests in Richmond, Va., as general superintendent of the Richmond Passenger & Power Company, of that city, has resigned that position and will engage in consulting engineering. Mr. Trafford is a member of the American Institute of Electrical Engineers, and is a widely-experienced and thoroughly-grounded engineer in central station and kindred branches.

MR. J. J. CARTY, the well-known telephone engineer, was elected last month to the presidency of the New York Electrical Society. Mr. Carty is one of the foremost of the Bell Telephone Company's engineers, and is the inventor of several fundamental features of modern telephone equipment, such as the Carty bridging bell. Mr. Carty has been an active and valued member of the New York Electrical Society for several years, as well as a prominent member of the American Institute of Electrical Engineers; he is at present the senior member of the Board of Managers of the Institute.

TRADE PUBLICATIONS.

DIRECT-CURRENT MOTORS AND DYNAMOS. The Holtzer-Cabot Electric Company, Boston, Mass.—Bulletin No. 145, devoted to Type E motors and dynamos, which are of the self-contained, semi-enclosed and enclosed types.

RECORDING VOLTMETERS, AMMETERS AND WATTMETERS. The Bristol Company, Waterbury, Conn.—Catalogue No. 10, containing illustrations and very complete price lists of these well-known recording station instruments.

DIRECT-CURRENT CIRCUIT-BREAKERS. Western Electric Company.—A handsome catalogue devoted to automatic limit switches for direct-current circuits. These switches are built in both single-pole and double-pole forms, and for direct-current circuits up to 600 volts and 2000 amperes.

MECHANICAL AND ELECTRICAL PROPERTIES OF LAVITE. The D. M. Steward Manufacturing Company, Chattanooga, Tenn.—This is an unpretentious but extremely interesting folder, presenting complete information as to the properties of "Lavite," the well-known insulating material manufactured by the Steward Company.

ENGINE TYPE RAILWAY GENERATORS. Stanley Electric Manufacturing Company, Pittsfield, Mass.—This is bulletin No. 134, containing an illustrated description of the latest Stanley direct-current generator. This is, of course, a multipolar machine, and the details of construction will be of much interest to operating engineers.

SPIRAL RIVETED PIPE. American Spiral Pipe Works, Chicago.—A very complete catalogue of spiral piping, containing a brief description of the pipe, some testimonials from prominent users, and tabulated data and price-lists relating to this product, as well as black and galvanized flange fittings for use in connection with the spiral pipe.

THE SOURCE OF THE ELECTRIC LIGHT. Crocker-Wheeler Company, Ampere, N. J.—A well-executed booklet, containing illustrations of some representative plants in which Crocker-Wheeler generators are used, together with some well-put arguments relating to the merits and applicability of Crocker-Wheeler apparatus.

SMITH-VAILE PUMPING MACHINERY. The Stillwell-Bierce & Smith-Vaile Company, Dayton, Ohio.—This is general catalogue No. 53, and is of the complete and handsomely-executed style characteristic of this company's literature. The catalogue contains illustrations and complete tabulated data relating to all of the extensive lines of Smith-Vaile pumps.

FACTORY ACCIDENTS. Consolidated Engine-Stop Company, New York.—This is a handsomely-executed booklet, containing a description of the Monarch engine-stop and speed-limit system, together with a list of users and a large number of strong testimonials to the merits of the system as a preventative of accidents from runaway engines.

THREE-WAY AND FOUR-WAY KNIFE SWITCHES. W. S. Hill Electric Company, New Bedford, Mass.—Bulletin No. 110, containing an illustrated price-list of knife-blade switches for circuits of 250 volts and upward, and built in either three or four-way form. An ingenious construction has been adopted which enables the builder to maintain a wall of insulating material between opposite poles of all three or all four pairs of contact jaws.

INSTALLATION AND OPERATION OF "WOOD" ARC LIGHTING APPARATUS. Fort Wayne Electric Works.—Instruction Book No. 3014, a copy of which should be in the hands of every central station engineer who has anything to do with the well-known "Wood" arc lighting apparatus built by the Fort Wayne Works. The system is very fully explained in detail, and complete instructions are given for setting brushes, adjusting the regulator, and all other operations necessary to the successful performance of the apparatus.

BUSINESS NEWS

GENERAL INCANDESCENT ARC LIGHT COMPANY, New York, has removed its Chicago office from 48 West Jackson Boulevard to 1218 Marquette Building.

BROWN-CORLISS ENGINE COMPANY, Corliss, Wis., is on the lookout for good representatives throughout the country to handle its well-known heavy-duty Corliss engines, hoisting machinery, compressors, etc.

F. N. MANROSS, Forestville, Conn., has had to double his factory facilities in order to keep abreast of the demand for small springs. Mr. Manross makes a specialty of delicate coil and other springs for fine work, such as in electrical instruments.

AMERICAN SCHOOL OF CORRESPONDENCE, Chicago, informs us that the United States government has adopted its instruction papers in electrical and mechanical engineering as text books for use in the School of Submarine Defense, at Fort Totten, N. Y.

THE SHELBY ELECTRIC COMPANY, Shelby, Ohio, has under way a large wing extension to its present factory plant, which will double the capacity of the plant. This expansion has, of course, been rendered necessary by the demand for the Shelby "Useful Light" lamps.

AMERICAN ELECTRICAL HEATER COMPANY, Detroit, Mich., is now located in its new factory, and announces that it has ample facilities for filling orders promptly. The company states that the demand this year for its appliances has been larger than in any previous year.

MANHATTAN ELECTRICAL SUPPLY COMPANY, New York, has brought out a new polarity indicator, which is said to embody improvements over previous instruments of this kind. One improvement noted consists of a projecting shield, which prevents injury to the glass tube while being carried in the pocket or tool bag.

THE BUFFALO STEAM PUMP COMPANY, North Tonawanda, N. Y., has been purchased by William F. and Henry W. Wendt, owners of the Buffalo Forge Company and the George E. Squier Manufacturing Company. The North Tonawanda Works of the Pump Company will be continued as heretofore, but the main offices will be located in Buffalo.

DULUTH STOKER COMPANY, Duluth, Minn., recently closed a contract with the American Steel & Wire Company for eight stokers, to be installed under eight boilers of 320 horse-power each. These stokers will be built in Chicago. The Duluth Company is also installing important stoker equipments at Detroit, South Chicago, Cleveland and other centers.

AMERICAN STOKER COMPANY has removed its headquarters from New York to the factory at Erie, Pa., where all correspondence should hereafter be addressed. J. S. Van Cleve, president of the Erie Foundry Company, has been elected general manager of the American Stoker Company, and Herbert D. Lloyd, vice-president and treasurer.

THE WILLARD STORAGE BATTERY COMPANY, Cleveland, Ohio, recently received an order from the Wilmington City Electric Company for the necessary elements to enlarge the Willard battery now in use at Wilmington from 2000 ampere-hours capacity to 3400 ampere-hours. The Willard Company states that the original battery has been in use every day for five years without renewals.

THE R. THOMAS & SONS COMPANY, East Liverpool, Ohio, the well-known manufacturer of porcelain insulators, has in preparation a very comprehensive catalogue which will include every approved type of high-voltage insulator. This catalogue will differ from the usual style of such publications in that the contents will consist chiefly of illustrations, very little reading matter being incorporated.

THE COMMERCIAL ELECTRIC COMPANY, Indianapolis, Ind., notwithstanding several enlargements of the factory quarters heretofore occupied, have been compelled by reason of increased business to establish an entirely new plant, which has accordingly been done. The company is now installed in the new quarters, which are located at Twenty-first Street and Northwestern Avenue and have a capacity of about four times that of the old plant.

PITTSBURG PIPING AND EQUIPMENT COMPANY is the style of a company recently organized at Pittsburg, Pa., by George H. Danner, Charles R. Rall and Joseph K. Smith, for the purpose of carrying on a general pipe-fitting, pipe-bending and machine shop business. The three gentlemen named have been for many years past prominently connected with the Best Manufacturing Company, and all are thoroughly experienced in the chosen line of work.

THE ELECTRIC STORAGE BATTERY COMPANY recently closed a contract with Mr. A. B. DuPont, vice-president of the St. Louis Transit Company, for the installation of a 3000-kw. battery, to be used in a sub-station with rotary converters, having a capacity of 6000 kilowatts. The battery will smooth out the fluctuations and assist in carrying the morning and evening peaks. It is interesting to note that this contract is said to cover the largest individual installation of storage batteries in the world for railway service.

THE LAGONDA MANUFACTURING COMPANY, of Springfield, Ohio, reports that the past month has been the best they have ever had since they commenced the manufacture of tube cleaners. The Company has been crowded out of the factory which it has occupied for the past year, and has just built a factory of its own which is greatly enlarged, and equipped it throughout with special tools and machinery adapted for the particular work to be done. Even in the new quarters, the company is compelled to run over-time in order to keep up with orders.

GERMANIA ELECTRIC LAMP COMPANY, Harrison, N. J., has inaugurated a new practice in electric lamp packing, which will doubtless be highly appreciated by lamp buyers. This consists of packing the lamps singly in corrugated pasteboard boxes, each box having a label pasted on the end which indicates the candle-power, voltage and type of base of the lamp. The company has established a New York office at 220 Broadway, and has also established a Pittsburg agency; The Engineering & Equipment Company, 529 Bissell Building, Pittsburg, will hereafter handle Germania lamps in that section.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Chicago and Rochester, recently sold to the Kearny (Mo.) Telephone Company a 100-drop switchboard and 200 instruments. The company has also closed a contract for telephone equipment to be used on the division of the Southern Pacific Railroad between El Paso and New Orleans. Copper full metallic circuits will be used between the two cities, and grounded circuits from stations to section instruments. It is proposed to install at every blind siding a telephone equipment, so as to enable wrecking crews to communicate immediately with the dispatcher.

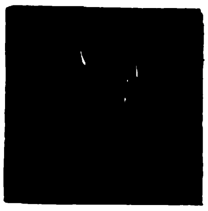
THE B. F. STURTEVANT COMPANY, Boston, Mass., is making a conspicuous success of ventilating and heating outfits for telephone exchanges. The New England Telephone & Telegraph Company, of Boston, which operates one of the most completely-equipped exchanges in the country, has put in a Sturtevant ventilating and heating outfit, consisting of a steel plate fan direct-driven by a vertical engine, and arranged to force air through a pipe coil heater which is by-passed, and the by-pass fitted with a special hot and cold damper automatically controlled by thermostats. A somewhat similar equipment is in use at the exchanges of the Twin City Telephone Company, St. Paul, Minn.

THE CLIMAX STEAM JOINT CLAMP and the H. H. steam trap, manufactured by James McCrea & Co., Chicago, are carried in stock by some dealer in every large city. Among those that have recently placed stock orders are Powell Eng. & Supply Company, St. Louis; Payne & Joubert, New Orleans; Hyman Supply Company, New Bern, N. C.; E. L. Wilson Hardware Company, Beaumont, Tex.; A. H. Busch Company, Los Angeles; Plant Supply Company, San Francisco; Gauld & Kline Company and Hallidie, Henshaw & Bulkley Company, Portland, Ore.; Puget Sound Mach. Depot, Seattle, Wash.; Holley, Mason & Marks Company, Spokane; Western Mining Supply Company, Butte, Mont.; Mine & Smelter Supply Company and Utah Mining Mach. & Supply Company, Salt Lake City, Utah; and E. Keeler Company, Williamsport, Pa.

THE LEEDS & NORTHRUP COMPANY, Philadelphia, Pa., succeeded on June 1st to the business of Morris E. Leeds & Co. The change is a growth and expansion rather than a transfer of that business. Mr. M. E. Leeds, who has been the managing member of the firm of Leeds & Co., is the president of the new company, and will devote himself particularly to the sales department. Dr. Edwin F. Northrup is the secretary, and will have charge particularly of the manufacturing. His training and talents fit him in a very unusual degree for this position in an establishment manufacturing scientific instruments. The Leeds & Northrup Company has discontinued the exclusive selling agencies of M. E. Leeds & Co., and particularly requests that all correspondence in regard to apparatus of their manufacture be addressed to the company directly.

THE CONVENTION SPECIAL of the New York Central Railroad, which carried delegates from New York and Boston to the recent electric light convention, was an exceptionally nice train, composed of five parlor cars, a dining-car, and a combination buffet, smoking and baggage car. The train left New York at one o'clock on Sunday afternoon, May 24, and made a very fast run over the New York Central and Michigan Central tracks, arriving in Chicago between 12 and 12.30 p. m. the next day. The railroad company had a representative on board who, together with the regular train crew, extended every possible courtesy and looked after the comfort and convenience of the passengers to the fullest extent. It was a very pleasant trip, and nothing was left undone which could contribute to the comfort of those on the train. The Boston contingent was taken on board at Albany.

A BIG STEAM TURBINE CONTRACT.—One of the largest contracts for steam turbine and electrical power machinery recorded in American territory has just been closed by Westinghouse, Church, Kerr & Co., with the Philadelphia Rapid Transit Company, covering steam turbine-generators aggregating 15,000 kilowatts, and other electrical generating and converting machinery aggregating 35,000 kilowatts, for equipping the new Rapid Transit subway and elevated system, now under construction in Philadelphia. The most interesting feature of the equipment is that steam turbines are to be used exclusively for power generation in the new station. There will be three turbine-generators installed, each of 5000 kilowatts normal capacity, the turbines to be of the type now being built by The Westinghouse Machine Company for large powers. The turbines will be direct-connected to Westinghouse three-phase 25-cycle alternators, and the units will run at 750 r.p.m.



BELTS WON'T SLIP
IF YOU COAT THE PULLEY WITH
WARREN'S PULLEY COVER PUT ON WITH A BRUSH.
125 SQ. FT. $12.00; 40 SQ. FT. $5.00. ~ TO DAY IS A GOOD DAY TO ORDER
THE WARREN COMPANY, INC., MFRS., 253 N. FRANKLIN ST., CHICAGO, ILL.

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has every advantage afforded by a comprehensive telephone system; incidentally, his name appears in the best of all directories.
Low Rates. Efficient Service.
NEW YORK TELEPHONE CO.
15 Dey Street, 220 West 124th Street,
111 West 38th Street, 614 East 150th Street.

SOLID TRAINS TO NORTHERN MICHIGAN
The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.
All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

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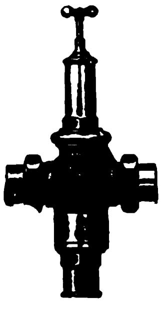


The MASON Reducing Valves
Are the World's Standard Valves.
For automatically reducing and absolutely maintaining an even steam or air pressure.
They are adapted for every need and guaranteed to work perfectly in every instance.
Write for full information and splendid references.
THE MASON REGULATOR CO., Boston, Mass., U. S. A.

American Electrician.

Vol. XV. New York, August, 1903. No. 8.

MODERN RAILWAY POWER STATION AND SUB-STATIONS.

NEW HIGH TENSION ALTERNATING-CURRENT INSTALLATION OF THE BERKSHIRE STREET RAILWAY COMPANY AT PITTSFIELD, MASS.

BY W. G. VIALL.

One of the finest interurban properties in New England is that of the Berkshire Street Railway Company. Starting in the town of Cheshire, Mass., where connection is made with the Hoosac Valley Street Railway of North Adams, the Berkshire Street Railway runs through the towns of Cheshire and Berkshire to Pittsfield, whence the line strikes south, touching the towns of Lenox, Lee, Stockbridge, Great Barrington and Sheffield, to the Connecticut state line, forming practically a continuous electric railway from the state line of Vermont to that of Connecticut, and traversing the extreme western end of Massachusetts. In the not too distant future it is the expectation of the Berkshire company to extend its lines so as to connect with the lines of the Albany & Hudson Railway & Power Company, running between Albany and Hudson, N. Y. Connection will also be made with the Western Massachusetts Street Railway Company's lines, now being built between Westfield and Lee. These lines will also connect with the lines running to Springfield.

In arranging the power scheme, consideration was given to the general territorial lay-out, as well as to the present and future demands of the service. Decision was finally made in favor of a central generating station at Pittsfield, Mass., with a sub-station at Lee and another at Housatonic, the former of which is about 10 miles distant from Pittsfield and the latter 20 miles. Three-phase current at 13,300 volts is generated at the central generating station and transmitted directly to the transmission lines without the use of step-up transformers. This current is stepped down to 380 volts for use at the rotaries, of which there are two 300-kw. machines in the main station and two 250-kw. machines in each of the two sub-stations. The rotaries deliver direct current at 600 volts to the trolley wire. The general di-

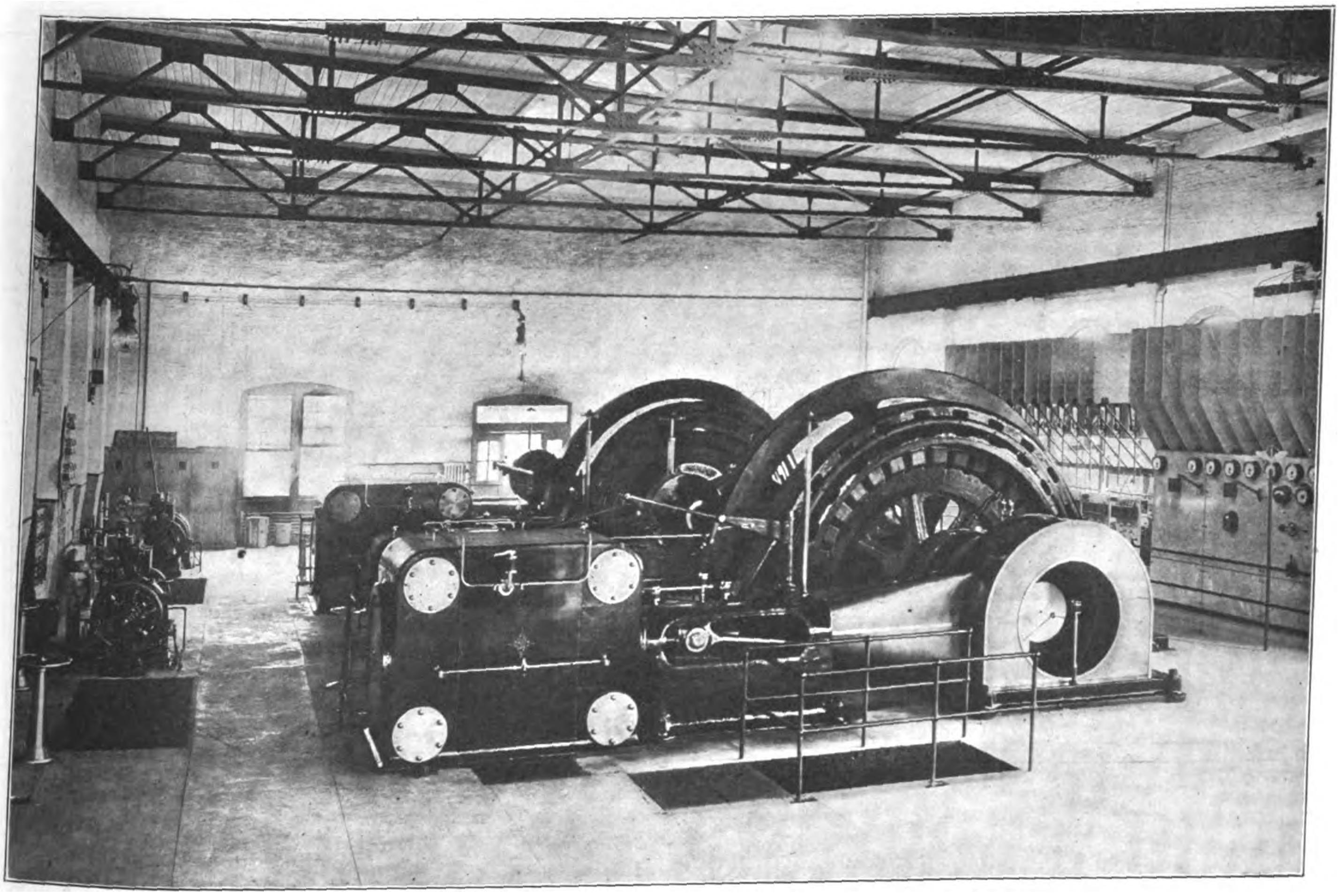


FIG. I.—GENERAL VIEW OF ENGINE ROOM IN MAIN POWER STATION OF BERKSHIRE STREET RAILWAY COMPANY.

mensions of the power house are 108 feet wide by 110 feet long, the engine room being 107 by 61 feet and the boiler room 42 by 95 feet, a brick wall separating the two. The engine-room floor is 8 feet 8 inches above the level of the boiler-room floor, and below the engine room is a basement the floor of which is 12 feet below that of the engine room. This forms a condenser pit wherein are located the condensers and steam and water piping, also the primary heaters, thereby leaving the engine room unobstructed in this respect.

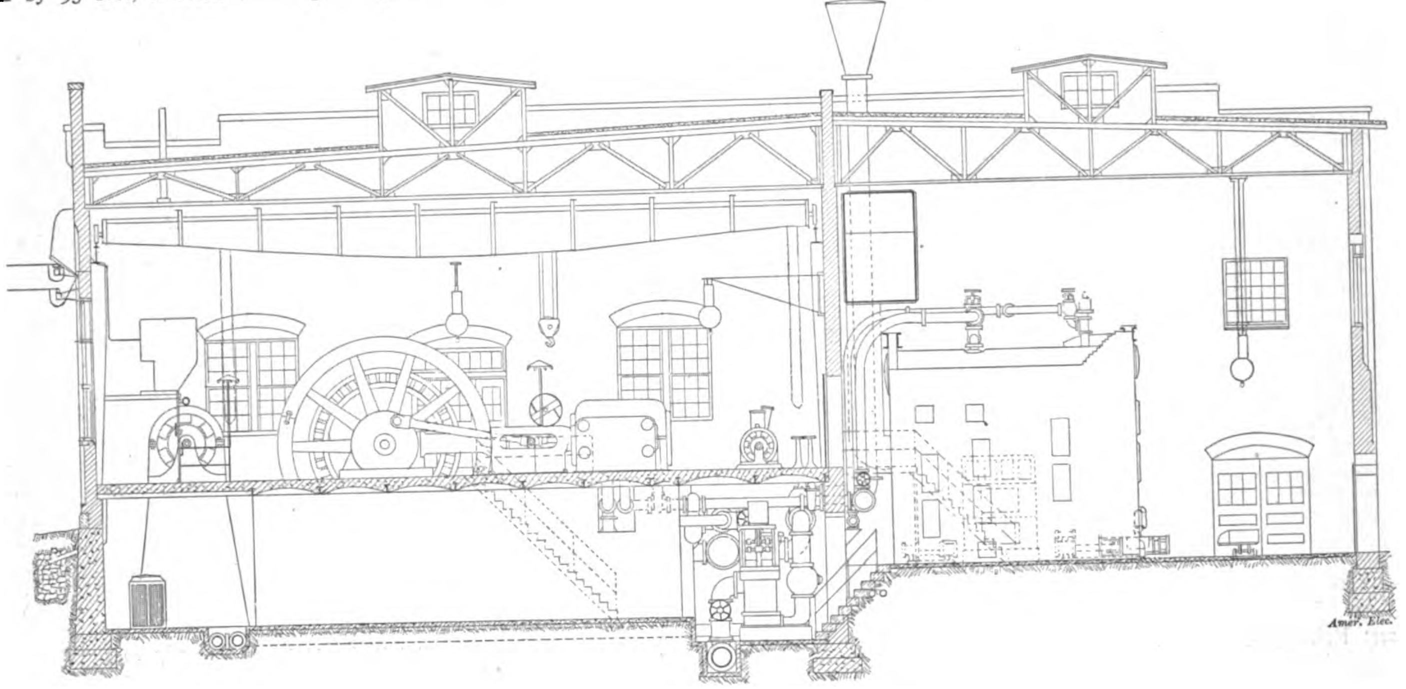


FIG. 2.—CROSS-SECTIONAL ELEVATION OF POWER STATION.

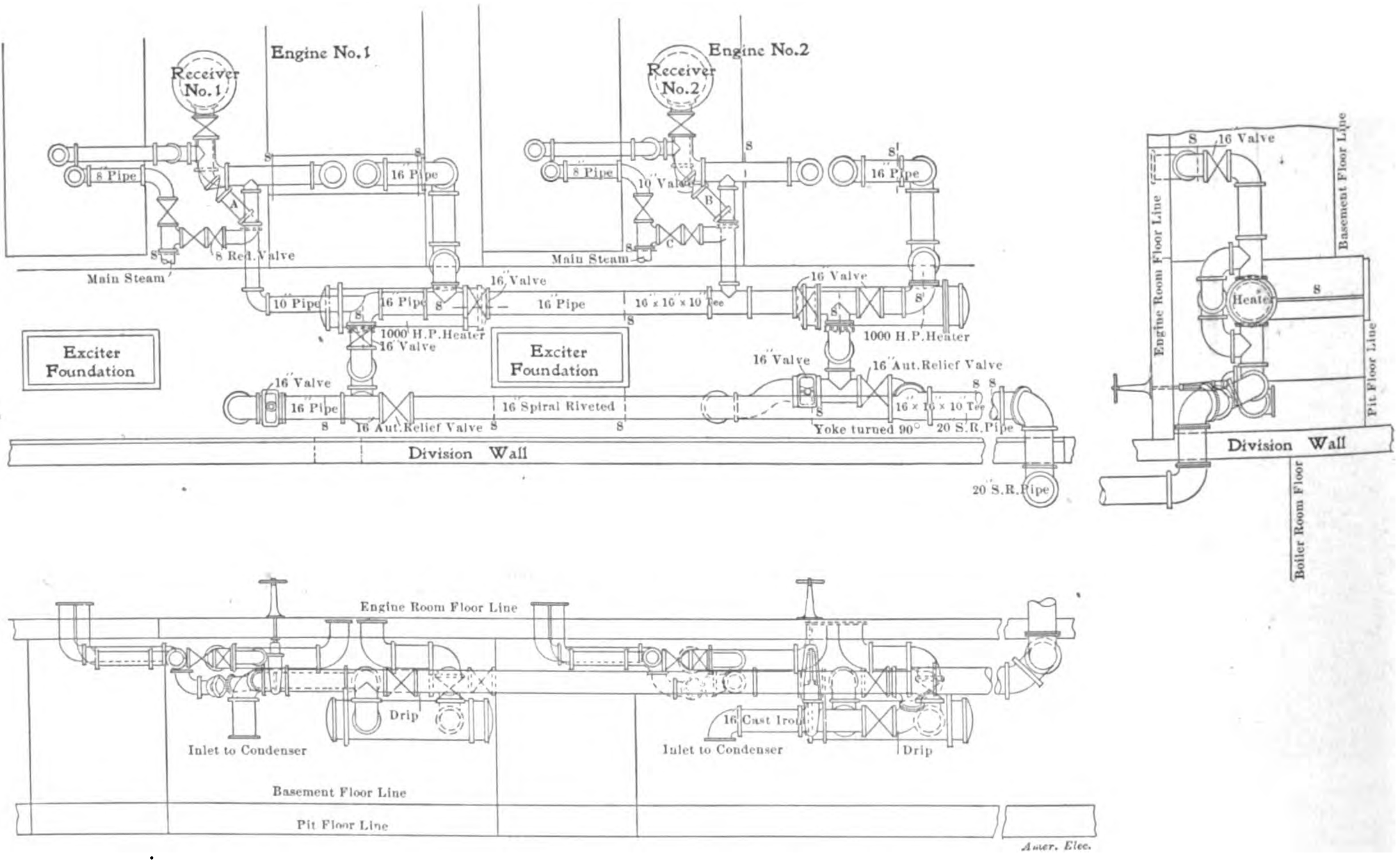

Engine No.1
Receiver No.1
8 Pipe
A
8 Red. Valve
S
Main Steam
16 Pipe
10 Pipe
16 Pipe
16 Valve
1000 H.P. Heater
16 Valve
Exciter Foundation
16 Valve
16 Pipe
16 Aut. Relief Valve
Engine No.2
Receiver No.2
8 Pipe
10 Valve
B
C
Main Steam
16 Pipe
16 Pipe
16 x 16 x 10 Tee
16 Valve
1000 H.P. Heater
Exciter Foundation
16 Spiral Riveted
16 Valve
16 Aut. Relief Valve
16 x 16 x 10 Tee
Yoke turned 90°
20 S.R. Pipe
20 S.R. Pipe
Division Wall
16 Valve
Heater
Engine Room Floor Line
Basement Floor Line
Pit Floor Line
Division Wall
Boiler Room Floor
Engine Room Floor Line
Drip
Inlet to Condenser
16 Cast Iron
Inlet to Condenser
Drip
Basement Floor Line
Pit Floor Line
Amer. Elec.

FIG. 3.—PLAN VIEW AND ELEVATION OF MAIN EXHAUST PIPING.

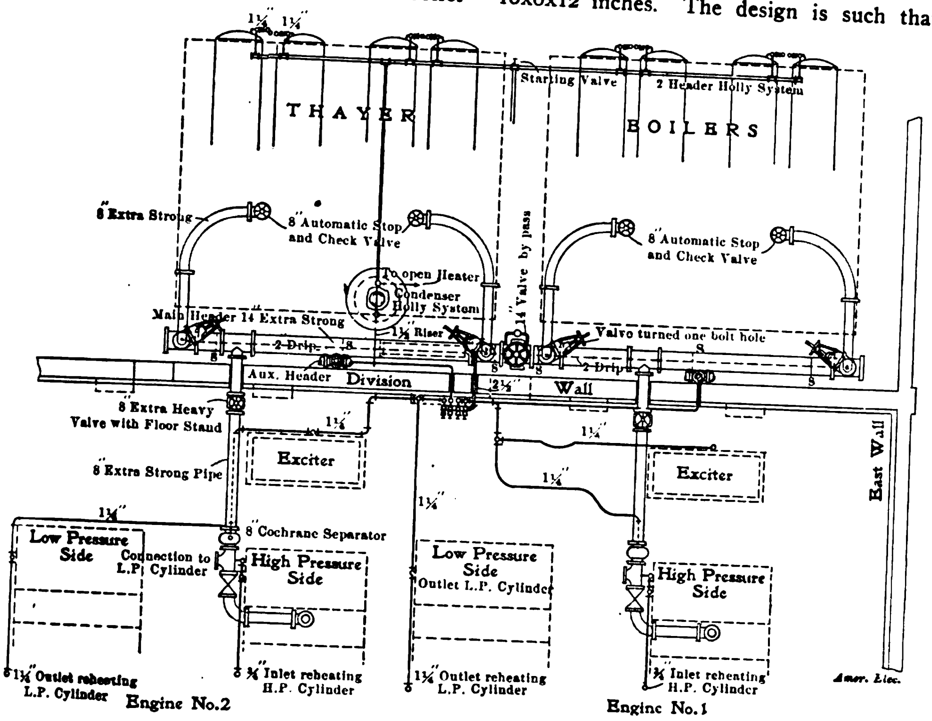
Steam is generated in four 380-h.p. water-tube boilers set in two batteries, built by the Aultman & Taylor Machinery Company, of Mansfield, Ohio. Each boiler has 3,930 square feet of heating surface arranged in 4-inch tubes in sixteen sections, each section being twelve tubes high. The grate surface of each furnace is 69 square feet, and steam is carried at 150 pounds pressure. The boilers are hand fired, bituminous coal being brought to the rear wall of the power house on an elevated spur from the main line of the Boston & Albany Railroad and dumped in front of the door leading to the boiler room. It is carried to the furnace doors, as shown by Fig. 7, on specially constructed side-dumping hand cars running on narrow-gauge tracks. Cars are also provided for removing the ashes. This coal-handling tramway was installed by The Hosher-Platt Company, of New York City. A Custodis stack, 75 feet 8 inches high and 8 feet in diameter at the top, adjoins the power house.

For supplying water, each condenser has a 10-inch independent cast-iron suction pipe leading from a cold well 10 feet deep sunk in the bed of the Housatonic

River. There is a 6-inch suction pipe leading to the boiler feed-pumps in the boiler room. The hot well is outside the building, the discharge pipes to the well from the condensers being 16 inches in diameter or 2½ times the area of the injection pipe. The connection from the well to the feed-pump is 6 inches in diameter. The intake pipes also have connection with the city water mains, so that there is no question of the available supply of water. A 6x6x6-inch Warren duplex pump, made by the Warren (Mass.) Steam Pump Company, discharges water through a 4-inch wrought-iron line to the primary heaters, and from them in a brass pipe to a 2000-h.p. Cochran auxiliary feed-water heater, furnished by the Harrison Safety Boiler Works, of Philadelphia. The feed-water pumps are of Warren make with cylinders 10x6x12 inches. The design is such that the small or low-pressure pump can also discharge directly into the Cochran heater and the boiler feed-pumps can also receive the water from the hot and cold wells and pump either directly into the boilers or through the primary heaters and thence into the boilers. The open heater receives the steam from the exciter units and the steam pumps, also the condensation of the heating system for the building, and the drips from the engine receivers, each of the receivers being provided with a trap for that purpose. The auxiliary exhaust is cross-connected to the main exhaust in the boiler room by a valve in the cross-section, so that when desired the main exhaust riser can be used to carry off the exhaust from the auxiliary plant, or the exhaust from the main engines may be utilized in part in the auxiliary or secondary heater. The boiler feed-pumps can be controlled by means of an automatic valve inserted in the live steam supply to them, this valve being actuated by the level of water in the heater.

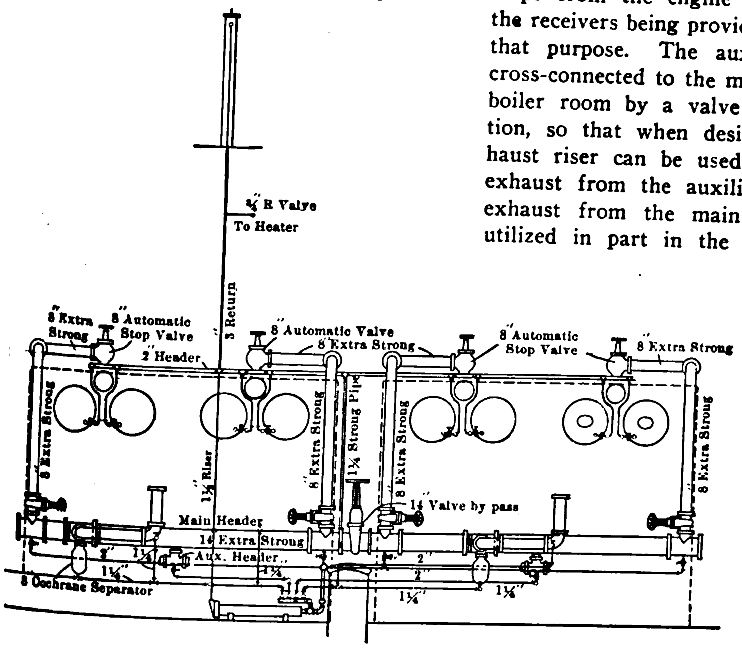
All the steam piping is extra strong with Chapman valves and Crane fittings. The steam piping system includes two steam headers, one 14 inches in diameter for the main engine and the other for the auxiliary apparatus. An 8-inch connection starting from an automatic stop-and-check valve and bending horizontally and then vertically downward to the heater, where there is a gate valve controlling the boiler supply pipe, leads from the cross-connection between the two 42-inch drums on each boiler. The header is about 6 feet above the floor. Steam is conveyed to each engine through an 8-inch connection leading horizontally from the header to a point beneath the engine-room floor directly under the engine cylinder. The connection there turns upward through the floor to the cylinder, first passing through a Cochran separator. The piping is so arranged that live steam can be fed to each of the cylinders should occasion require it. In the branch leading to the low-pressure cylinder is a Kieley valve, by means of which the mean effective pressure in the low-pressure cylinder can be regulated throughout a considerable range. Condensation is taken care of by an adaptation of the Holly system, installed by Westinghouse, Church, Kerr & Co.

In the lay-out, as designed for the exhaust piping, the high-pressure cylinder exhausts into a receiver, or when the low-pressure cylinder is out of commission, into the main exhaust header. This header is 16 inches in diameter and towards each end feeds through a primary feed-water heater. This heater is arranged with valves, so that if necessary the exhaust into one end can pass through the exhaust outlets corresponding to the other unit. The feed-water heaters are 1000-h.p. units of the Goubert horizontal type. Just be-

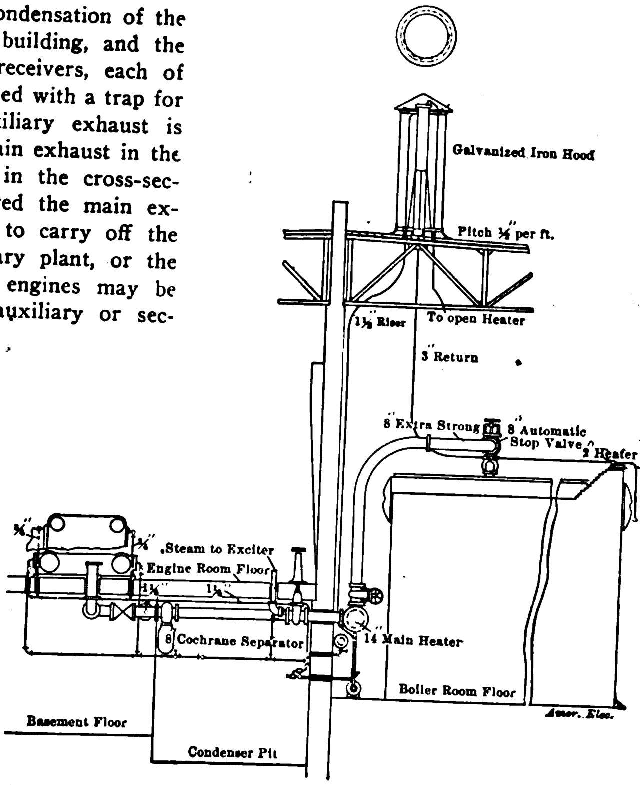


1¼" 1¼"
THAYER BOILERS
Starting Valve
2 Header Holly System
8" Extra Strong
8" Automatic Stop and Check Valve
8" Automatic Stop and Check Valve
To open Heater
Condenser
Holly System
14" Valve by pass
Main Header 14" Extra Strong
2" Drip
1¼" Riser
Valve turned one bolt hole
2" Drip
Aux. Header
Division Wall
2½"
8" Extra Heavy Valve with Floor Stand
1¼"
8" Extra Strong Pipe
Exciter
Exciter
1¼"
1¼"
1¼"
East Wall
1¼"
8" Cochrane Separator
Low Pressure Side
Connection to L.P. Cylinder
High Pressure Side
Low Pressure Side
Outlet L.P. Cylinder
High Pressure Side
1¼" Outlet reheating L.P. Cylinder
¾" Inlet reheating H.P. Cylinder
1¼" Outlet reheating L.P. Cylinder
¾" Inlet reheating H.P. Cylinder
Engine No.2
Engine No.1
Amer. Elec.

FIG. 4.—PLAN VIEW OF MAIN STEAM PIPING.



¾" R Valve To Heater
3" Return
8" Extra Strong
8" Automatic Stop Valve
2" Header
8" Automatic Valve
8" Extra Strong
8" Automatic Stop Valve
8" Extra Strong
8" Extra Strong
1¼" Riser
8" Extra Strong
1¼" Strong Pipe
8" Extra Strong
8" Extra Strong
14" Valve by pass
Main Header
14" Extra Strong
Aux. Header
8" Cochrane Separator
1¼"
1¼"
1¼"
2"



Galvanized Iron Hood
Pitch ¾" per ft.
1¼" Riser
To open Heater
3" Return
8" Extra Strong
8" Automatic Stop Valve
2" Header
¾" Steam to Exciter
Engine Room Floor
8" Cochrane Separator
14" Main Header
Boiler Room Floor
Basement Floor
Condenser Pit
Amer. Elec.

FIG. 5.—END AND SIDE ELEVATIONS OF MAIN STEAM PIPING.—FIG. 6.

yond the heaters are vertical twin jet condensers built by the Warren Steam Pump Company. At this point is the relief valve for service when running non-condensing. The auxiliary feed-water heater, together with the feed and circulating pumps, are located in the boiler room. The auxiliary header is just below the main header, near the wall separating the boiler and engine rooms. The connection from each boiler is fitted with an automatic valve at the boiler, and the battery is controlled by a gate valve immediately above the header. The connections to the exciter units, steam pumps and other auxiliaries are taken from the top. Figs. 4, 5 and 6 show the plan view and end and side elevations of the main steam piping, and Fig. 3 gives a plan and elevation of the main exhaust piping.

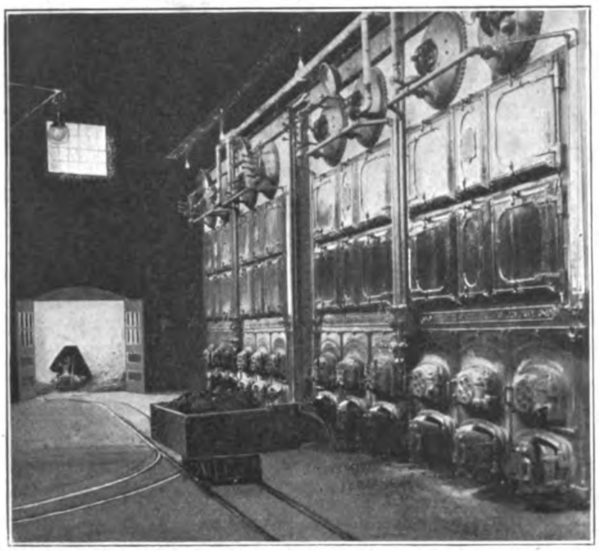


FIG. 7.—BOILER ROOM.

The main generating units are each driven by a 1200-h.p horizontal cross-compound condensing direct-connected Rice & Sargent engine, built by the Providence Engineering Works, Providence, R. I. The general dimensions of the engines are as follows:

Diameter of cylinders	22 and 44 inches.
Stroke of piston	48 inches.
Revolutions per minute	94
Diameter of middle portion of shaft	21 inches.
Main shaft journals	18x32 inches.

Under a steam pressure of 150 pounds and at one-quarter cut-off, the rating is 1120 horse-power; at six-tenths cut-off the rating is 2150 horse-power. As is usual in the Rice & Sargent design, the cylinders are made of close-grained cast-iron with faced heads and pistons and water relief valves at each end. The exhaust valves are shaped according to this company's patented design, the steam passages being formed in the valves themselves instead of in the cylinders. The valve gear is of the Rice & Sargent patented rotary 4-valve type with independent eccentrics for the steam and exhaust valves. The point of cut-off is controlled by the governor from zero to three-quarter stroke. The governor is of the improved inertia type, guaranteed to regulate within one per cent from no load to full load and within two per cent for any instantaneous variation under any condition of load. A Monarch engine stop is provided to immediately stop admission of steam to the cylinder should the governor become disabled. The governor has control of both cylinders, and the low-pressure gear may be manually controlled while the engine is in operation, so that the relation of cut-off from one cylinder to the other may be changed to suit the load. The receiver is of the overhead type with a capacity four times that of the high-pressure cylinder. The coils are sufficient to superheat the incoming steam so that there is no appreciable drop to the low-pressure cylinder. A 3-in. pop safety valve is provided on the receiver and set at 40 pounds.

The main generating units comprise two 750-kw. three-phase revolving field Westinghouse alternators, giving 32.6 amperes per phase at 13,300 volts and 25 cycles per second. The stationary armature is thoroughly protected and the design of the machine is such that it is impossible to come in contact with any of the high-potential parts. Each alternator is excited by its own exciter set consisting of a 20-kw. Westinghouse 125-volt generator driven by a small Westinghouse steam engine. These exciter units are shown at the left in Fig. 1, and at night, when the main engines are shut down, these units supply current for lighting the station and car house.

A view of the switchboard, which was installed by the Westinghouse Electric & Manufacturing Company, is shown by Fig. 8 herewith, and a diagram of the connections is given by Fig. 14. The board is of blue Vermont marble, 2 inches thick, polished on face and bevel. All of the metal parts on the face of the board are given a copper finish. The construction of the switchboard and its connections are shown so clearly in the illustrations and also in Fig. 9, which is a view taken from the rear, that further comment is unnecessary. Two 300-kw. rotary converters with their switchboard and six 100-kw. oil-cooled transformers complete the equipment of the main station. These converters are used to furnish direct current to the territory immediately adjoining the station and to the northern end of the line. Fig. 10 shows these machines and the

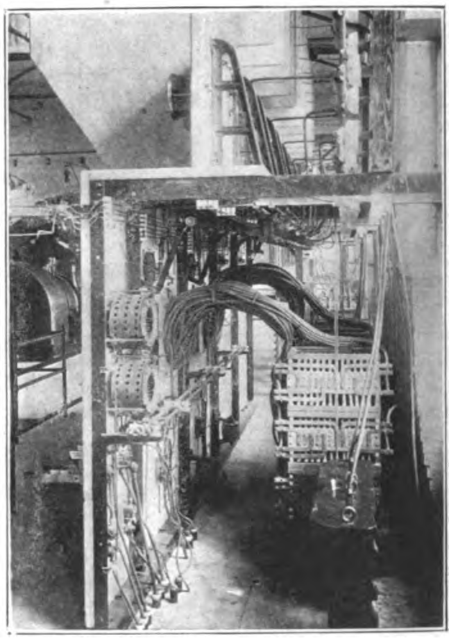


FIG. 9.—REAR OF MAIN SWITCHBOARD.

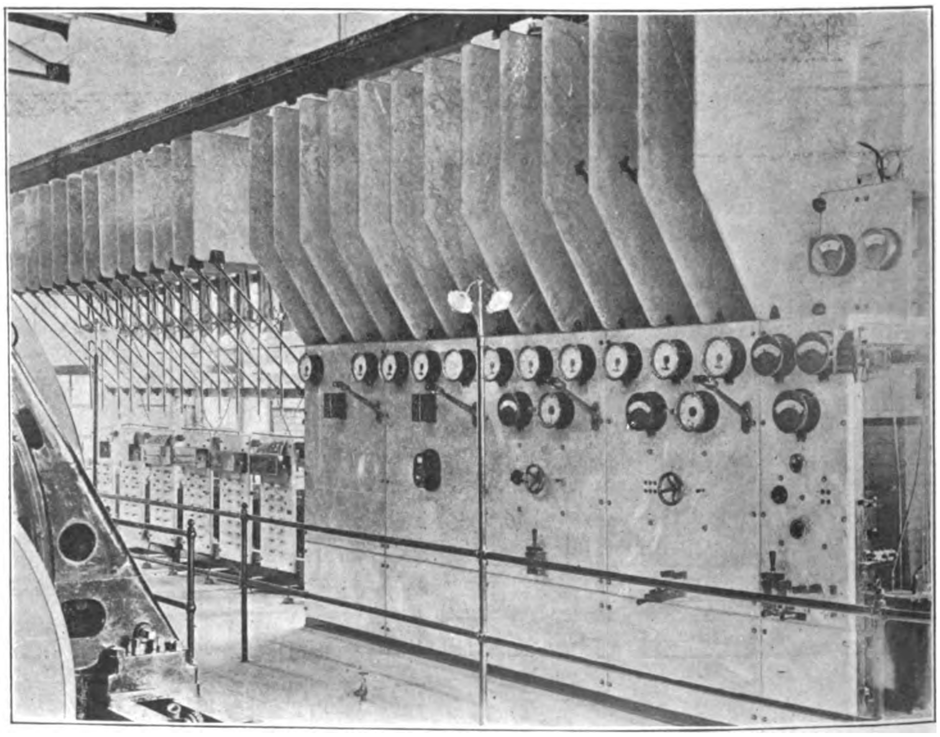


FIG. 8.—VIEW OF MAIN SWITCHBOARD.

switchboard. The connections are shown in Fig. 14. A system of compressed air is used for cleaning the electric machinery and furnishing air for the oiling system.

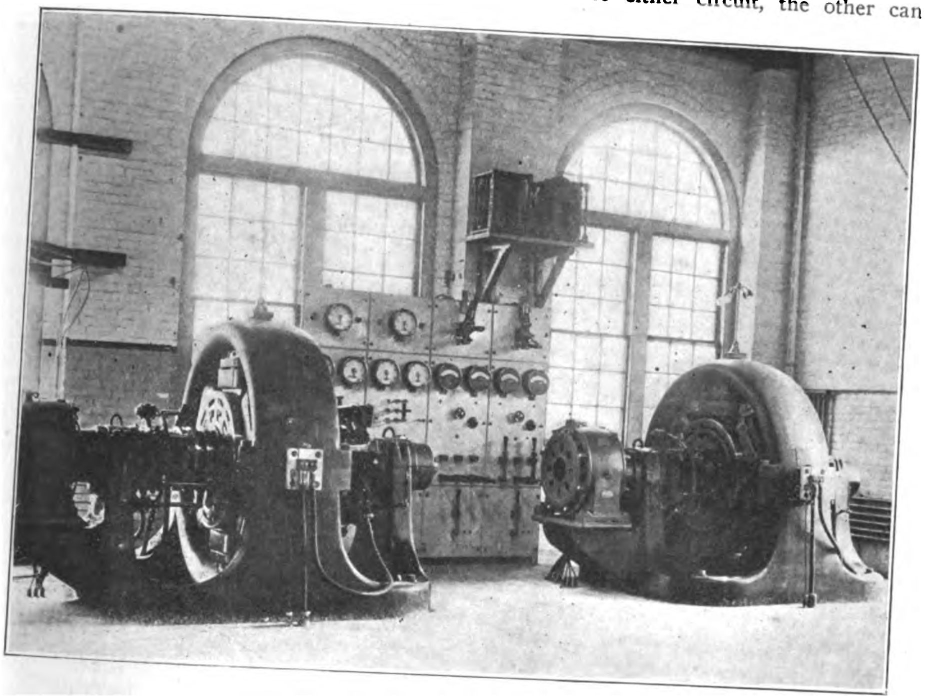


FIG. 10.—MOTOR-GENERATORS IN MAIN STATION.

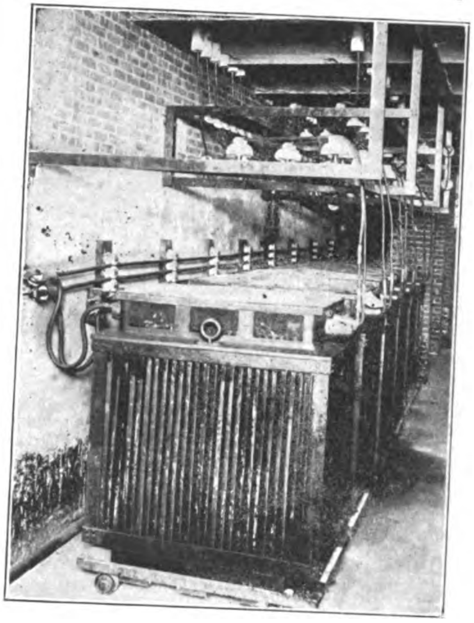


FIG. 12.—TRANSFORMERS IN MAIN STATION.

Fig. 13 is a view in the sub-station at Lee, showing the 250-kw. rotary converters and the static transformers. The plant is housed in a frame building, a portion of which is used as a dwelling for the sub-station attendant, the converters and transformers being in a one-story addition adjoining the rear of the building. The sub-station at Housatonic is located in the rear of the car house, and the electrical equipment is identical with that of the sub-station at Lee. A view of the equipment at this sub-station is given by Fig. 11.

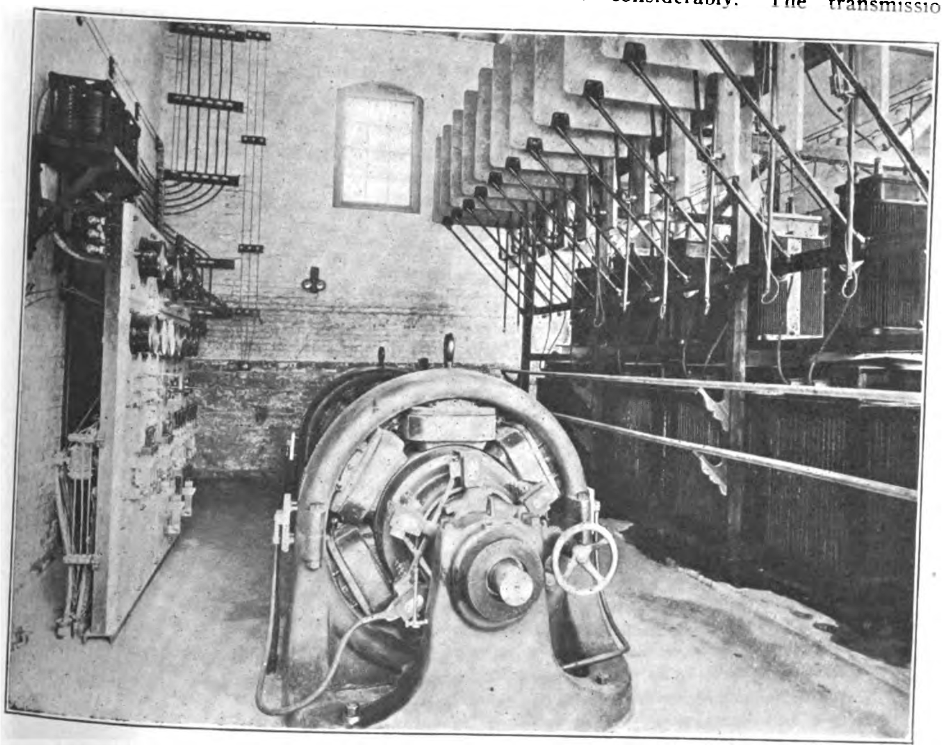


FIG. 11.—EQUIPMENT IN HOUSATONIC SUB-STATION.

The transmission lines from the main station in Pittsfield are in duplicate; that is, there is one circuit from Pittsfield to the Lee sub-station and another circuit from Pittsfield to the Housatonic sub-station. These are so arranged that in case of accident to either circuit, the other can be cut in. The transmission line does not follow the street railway line for the entire distance, the town of Pittsfield being cut out by a high-tension line around the city, and the town of Lee being similarly avoided by a line running over the turnpike. This not only avoids high-tension lines in the towns, but also shortens the transmission distance considerably. The transmission lines are of bare copper wire carried on two crossarms, the circuit to Lee being on one side of the pole and the circuit to Housatonic being on the other. Each circuit is arranged, as shown in Fig. 15, in the form of an equilateral triangle with sides 18 inches long. The pole-top shown herewith is the form used both where the transmission pole line follows the track and also where it goes across country. The insulators for the high-tension line are of glass having 7½-in. petticoats and supported on steel pins with glass sleeves. A four-point barb wire strung along the tops of the poles and grounded at every fifth pole affords lightning protection. No poles are guyed on the transmission line, the sharp turns at the poles being braced by stubs set on the inside of the curve. The feeders for the trolley are carried on a crossarm below the transmission arms and are tapped to the trolley wire every mile. Along the main line two No. 0000 hard-drawn copper-grooved trolley wires are used, supported by Craigehead flexible brackets on 35-ft. poles. The road is single track for a considerable distance, and the trolley wires are placed about 3 inches apart, except at the turnouts where they separate to accommodate both tracks.

Telephones are installed at all important points along the line. Each car is equipped with a portable telephone and a 15-ft. bamboo pole with two spring brass hooks at the top, and a long flexible twin wire with a jack plug at the other end for connecting to the telephone. The telephone wires are run along the pole lines about 18 feet above the ground, one above the other and separated about 15 inches, so that in case of accident communication may be had between the car and the main office from any point on the line. At every turnout, conductors signal the train dispatcher at the main station and report. An electric signal system, built by the United States Signal Company, of West Newton, Mass., and especially designed for single-track trolley roads, is used to show whether the section to the next turnout is free or not. The system consists of two signal boxes and two trolley boxes for every section of track between turnouts. The signal boxes, which are placed a short distance beyond the turnouts, are provided with windows of red and white glass, an incandescent lamp being placed behind each window. The boxes are connected by two No. 12 galvanized-iron wires. The armature of the lighting magnet is mechanically locked in place after it has operated the proper contacts and should the lamps be extinguished, owing to failure of current, they will be immediately relighted when the current is switched on again and can only be permanently extinguished by the action of the extinguishing magnet. This magnet unlocks the armature of the lighting magnet when the car leaves the block, thus replacing the signal in a position ready to work in either direction. When a signal is set either way, the signal for the opposite direction is mechanically locked out of service. The operation of this system is substantially as follows:

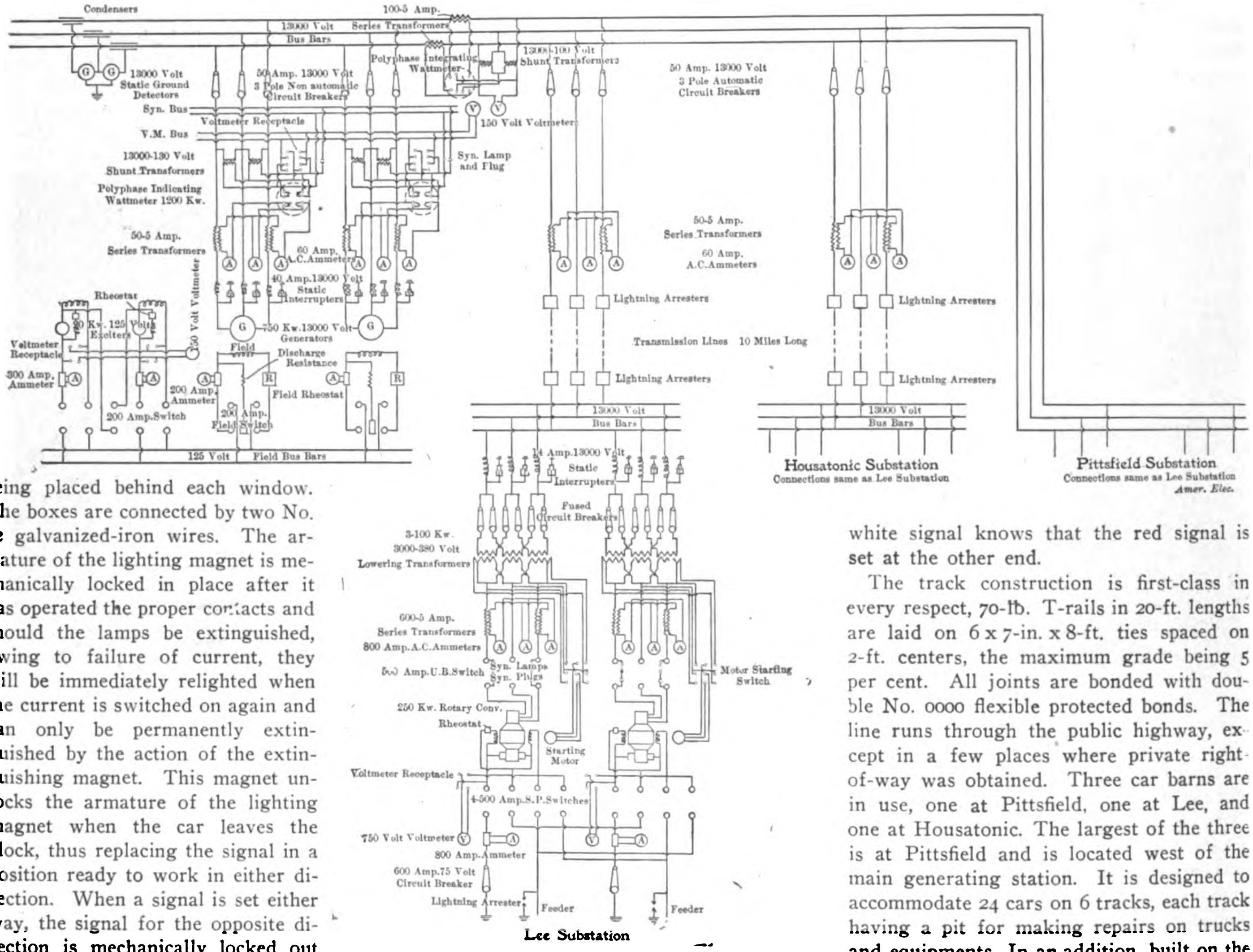

Condensers
100-5 Amp.
13000 Volt Series Transformers
Bus Bars
13000 Volt Static Ground Detectors
Syn. Bus
V.M. Bus
50 Amp. 13000 Volt 3 Pole Non automatic Circuit Breakers
Polyphase Integrating Wattmeter
13000-100 Volt Shunt Transformers
50 Amp. 13000 Volt 3 Pole Automatic Circuit Breakers
Voltmeter Receptacle
150 Volt Voltmeter
13000-130 Volt Shunt Transformers
Polyphase Indicating Wattmeter 1200 Kw.
Syn. Lamp and Plug
50-5 Amp. Series Transformers
60 Amp. A.C.Ammeters
40 Amp.13000 Volt Static Interrupters
Rheostat
50 Kw. 125 Volt Exciters
150 Volt Voltmeter
750 Kw.13000 Volt Generators
Voltmeter Receptacle
300 Amp. Ammeter
Field Discharge Resistance
Field Rheostat
200 Amp. Ammeter
200 Amp.Switch
200 Amp. Field Switch
125 Volt Field Bus Bars
Lightning Arresters
Transmission Lines 10 Miles Long
13000 Volt Bus Bars
Housatonic Substation
Connections same as Lee Substation
Pittsfield Substation
Connections same as Lee Substation
14 Amp.13000 Volt Static Interrupters
Fused Circuit Breakers
3-100 Kw. 3000-380 Volt Lowering Transformers
600-5 Amp. Series Transformers
800 Amp.A.C.Ammeters
500 Amp.U.B.Switch
Syn. Lamps
Syn. Plugs
Motor Starting Switch
250 Kw. Rotary Conv.
Rheostat
Starting Motor
Voltmeter Receptacle
4-500 Amp.S.P.Switches
750 Volt Voltmeter
800 Amp. Ammeter
600 Amp.75 Volt Circuit Breaker
Lightning Arrester
Feeder
Lee Substation
Amer. Elec.

FIG. 14.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

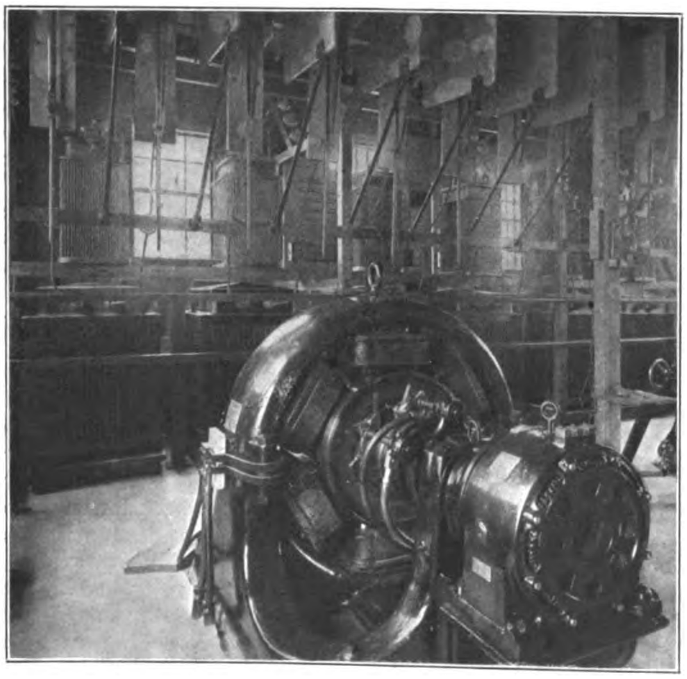


FIG. 13.—EQUIPMENT IN LEE SUB-STATION.

When a car enters a block it actuates the mechanism in the trolley box, causing current to pass for an instant through a magnet whose armature being thus attracted is locked in place; this closes the lighting circuit through a permanent connection to the trolley or feed wire and lights a white light at the end of the block near the car and a red light at the other end of the block. The two lamps being in series, both are lighted simultaneously, and a motorman entering the block and seeing the white signal knows that the red signal is set at the other end.

The track construction is first-class in every respect, 70-lb. T-rails in 20-ft. lengths are laid on 6 x 7-in. x 8-ft. ties spaced on 2-ft. centers, the maximum grade being 5 per cent. All joints are bonded with double No. 0000 flexible protected bonds. The line runs through the public highway, except in a few places where private right-of-way was obtained. Three car barns are in use, one at Pittsfield, one at Lee, and one at Housatonic. The largest of the three is at Pittsfield and is located west of the main generating station. It is designed to accommodate 24 cars on 6 tracks, each track having a pit for making repairs on trucks and equipments. In an addition, built on the side next to the street, are the main offices and employes' rooms, and in the addition on the other side of the building are the wagon rooms, stable, and sand and oil rooms. A repair shop is to be built at the rear end of the car barn, which will be equipped with modern appliances for making repairs and for painting. The car barn at Lee is a wooden building designed to accommodate 6 cars on 3 tracks, and the barn at Housatonic is designed to accommodate 3 cars on 2 tracks, one track being

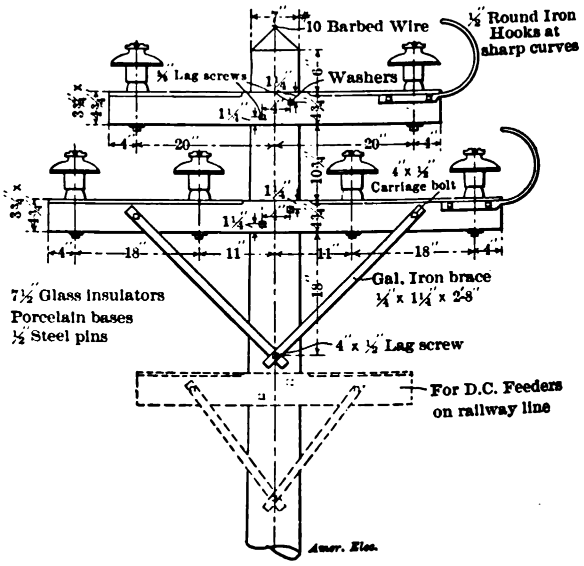

7"
10 Barbed Wire
½" Round Iron Hooks at sharp curves
⅜" Lag screws
Washers
1¼"
3¼" x 4¼"
4"
20"
20"
4" x ½" Carriage bolt
18"
11"
11"
18"
7½" Glass Insulators
Porcelain bases
½" Steel pins
Gal. Iron brace ¼" x 1¼" x 2'8"
4" x ½" Lag screw
For D.C. Feeders on railway line
Amer. Elec.

FIG. 15.—TRANSMISSION LINE.

shortened to provide a waiting room for passengers. The rear end of this barn is used for the sub-station. The tracks in both the Lee and Housatonic barns have pits for making minor repairs. The rolling stock consists of 47-ft. convertible cars, each of which is equipped with four Westinghouse No. 56 motors with Type K-14 controllers; Christensen air-brakes, with independent electric air compressors, are provided for each car.

The line now in operation is divided up as follows:

Great Barrington to Stockbridge	9.2 miles.
Stockbridge to Lee	5.7 miles
Lee to Lenox	3.6 miles
Lenox to Pittsfield	6.8 miles.
Pittsfield to Berkshire	5.7 miles.
Berkshire to Cheshire	4.2 miles.

◆◆◆

INTERNAL SEPARATORS FOR STEAM BOILERS.

BY R. T. STROHM.

The use of a steam separator on the main steam pipe near the engine is one method of obtaining dry steam; that is, commercially dry, and such a device will prevent any "slugs" of water from being carried over into the engine cylinder. But the separator located at this point has a disadvantage in that it does not return the moisture to the boiler; it frequently discharges the condensation into a waste drain. If it is desired to return this condensation to the boilers, however, it is necessary to use a trap or a steam loop, or to discharge into a hot well from which the water may be returned by pump.

Very frequently the steam is initially wet when it leaves the boiler and as it passes through the steam main this quantity of moisture is increased by reason of the condensation due to radiation of heat from the pipe. The moisture thus separated by the steam separator, even if returned to the boiler, will be considerably lower in temperature than if it had been separated before leaving the boiler. There are several devices the function of which is to dry the steam before allowing it to pass from the boiler to the main steam pipe. Such devices possess the advantage of keeping the moisture in the boiler, without reducing its temperature in the slightest, which is more economical than separating the same moisture outside the boiler and returning it by auxiliary apparatus.

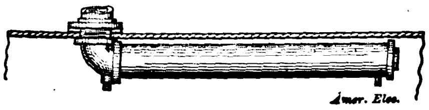


FIG. 1.—DRY PIPE.

Perhaps the first device used for drying the steam was the dry pipe, illustrated in Fig. 1. It consists of a pipe of about the same diameter as the steam pipe, held in position in the steam space of the boiler and attached to the steam pipe. It may be either an extension of the steam pipe as shown, or the steam pipe may be attached at the middle of the dry pipe. The end of the dry pipe is closed, and along its upper side it is perforated with a number of holes of small diameter. The number of these holes is such that their combined area is somewhat greater than the area of the steam pipe leading from the boiler. On the under side the dry pipe is fitted with drips through which the moisture collected in the pipe may flow freely into the boiler. The principle on which this device acts is that the wet steam, in passing through the small orifices in the upper side of the pipe, is robbed of most of its entrained water, allowing comparatively dry steam to pass into the main steam pipe.

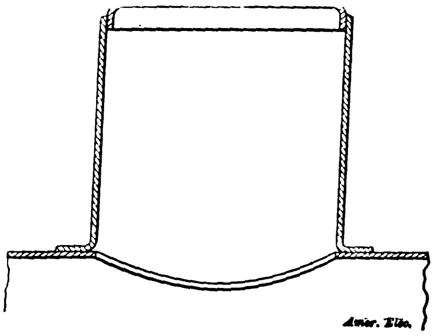


FIG 2.— STEAM DOME.

The dry pipe is used on a number of types of boilers, perhaps the most common being the marine type, although some locomotive boilers are thus provided. The builders of the Babcock & Wilcox and the Heine water-tube boilers make use of the dry pipe. In the former make of boiler, the dry pipe extends from end to end of the steam drum and has two outlets, one for the attachment of the safety valve and the other for connection to the main steam pipe. In the latter it is simply a short perforated pipe attached to the steam main just inside the shell of the steam drum.

The purpose of the steam dome used on the ordinary shell boiler is two-fold. In the first place it adds to the volume of the steam space and hence makes a larger steam reservoir. In the second place, it removes the steam to a greater distance from the boiling water, which is supposed to have the effect of drying the steam somewhat, since the entrained water particles will be free to fall out of the steam by reason of their own specific gravity. It is well known that water, when boiling, throws off particles of water at the surface. The steam particles, forming at the bottom or at least beneath the surface of the liquid, rise by reason of their comparative lightness. When they reach the surface, they burst through the surface film and in so doing throw a spray of water particles into the steam space. The more violent the boiling, the greater is the amount of spray thus thrown up, and this moisture will be carried along with the steam current unless means are taken to separate the two.

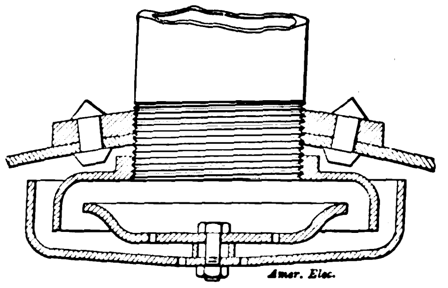


FIG. 3.—INTERNAL SEPARATOR.

Naturally, the greatest amount of steam is formed at the point where the greatest amount of heat is transmitted to the water per unit of area of heating surface. In the return tubular boiler this occurs above the grates, especially toward the rear of the grates, near the bridge. As a usual thing, the dome is located directly above the bridge wall, at the center of the middle sheet of the shell. It would seem, therefore, that it would be in just the proper place to pick up the wettest steam. This would be true if the boiler were merely a long drum, since the steam particles would then rise and break through at a spot almost vertically above the hottest portion of the furnace. But the tubes interfere to some extent with the upward circulation of the steam globules so that they are scattered and diffused over a considerable area at the surface, thus breaking through at numerous points. As a consequence of this extended disengagement surface there is usually no trouble from priming. It is only when the water level is carried too high, thus reducing the steam space and the area of disengagement surface, or when the fires are forced, that serious wetness of steam is likely to result.

Hence the steam dome operates in three separate ways in freeing the steam of moisture. It removes the steam outlet to a greater distance from the water level than would be possible if the outlet were placed in the shell itself and consequently there is less liability that the spray will be thrown up into the outlet; it also draws steam from a greater proportion of the steam space than would be the case if the outlet were a mere hole in the top of the shell; and finally, since the cross-section of the dome is so large compared to that of the steam pipe, the velocity of the steam in it is much less than in the steam pipe, which fact permits some of the moisture to be deposited before reaching the pipe, since the amount of moisture entrained by a current of steam is largely dependent upon the rate of flow of the steam.

The great objection to the steam dome is that it weakens the boiler shell. It is usually attached to the shell as indicated in Fig. 2, and as may be seen, a large hole is cut in the top of the middle sheet. This makes the boiler considerably weaker against longitudinal strains and it furthermore allows an easier distortion of the shape of the boiler. It is true that the flange of the dome tends to act as a reinforcing ring about the edge of the opening, but in spite of this the shell is weaker because of the dome. In order to obviate this effect, various methods of cutting the shell and of attaching the dome have been tried. The plate has been perforated with a number of small holes, but while this leaves it stronger against rupture, the distorting effect remains. The same is true, to a lesser extent, when a single hole the size of a manhole is cut in the plate under the dome.

The dry pipe, on the other hand, does not weaken the shell to any appreciable extent and it is a less expensive attachment also;

but it does not add to the steam space, as does the dome, which in turn may be considered disadvantageous.

Still another form of internal separator is that shown in Fig. 3. This consists simply of three shallow circular cast-iron dish-shaped plates, one within another, and placed at the end of the steam pipe leading from the boiler. The steam is thus caused to pass under and over these plates before it can get out of the boiler, and since the rims of the plates extend within one another the direction of the steam current is changed a number of times before the steam passes into the outlet. As is well known, the effect of changing the direction of flow suddenly is to set up a sort of circular motion at the point of change of direction and this in its turn induces centrifugal action. As a natural consequence, the heavier moisture particles contained in the current are thrown outward against the plates of the separator where they collect and drip back into the boiler, through the drain holes in the plates, while the steam passes on to the outlet in a dryer condition. The inertia of the water particles is another factor which aids in the separation. While moving in a straight line they acquire a certain momentum. The steam current changes direction quite readily, but the moisture particles, by reason of their inertia, tend to continue their rectilinear motion, which throws them against the plates or baffles.

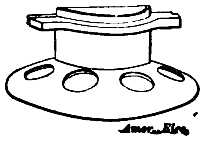


FIG. 4.

The same principles are made use of in the separator shown in Fig. 4. This type consists of a single casting, oval in section, which changes the direction of the steam current by the placing of holes in the casting, thus causing the separation of moisture.

Perhaps the most recent design of dry pipe and separator is that shown in Fig. 5. This is known as a mesh separator and superheater, and its construction is evident from the illustration. It is composed of a number of galvanized or copper wire screens which are placed between alternate rings of cast-iron, the series being held together firmly by bolts extending from end to end of the separator, and passing through lugs conveniently cast on the iron rings. The number of these meshes or screens varies from 25 to 30 and the area depends upon the size of the boiler outlet.

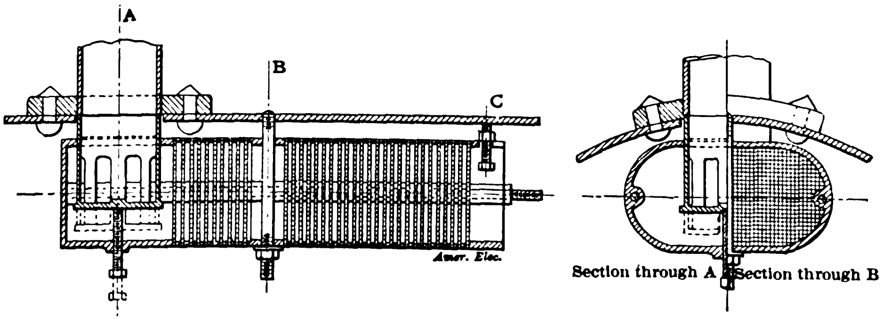


FIG. 5.—DRY PIPE AND SEPARATOR.

As may be seen, the end nearer the outlet is closed so that the steam must pass through the successive layers of wire mesh before it can reach the steam nozzle. The principle upon which this device acts is different from that employed in the previous designs mentioned. The current of wet steam, in passing through the first screen is broken up into a number of small streams, and the moisture globules entrained are also broken up into smaller particles. The same action occurs in passing through the second screen, the water particles being further reduced in size though increased in number. And so on, successively, throughout the length of the separator. The result is that by the time the steam has reached the collecting chamber beneath the outlet nozzle, its entrained water has been completely atomized. In such a condition this moisture will evaporate under the slightest application of heat and this heat is supplied from the steam itself. In passing through the meshes, the steam is slightly wiredrawn, the reduction of pressure between the first and the last screen being about one per cent. The heat thus set free evaporates the atomized moisture globules, and the result is dry steam at the boiler outlet.

The joints made by the cast-iron rings and the screens, and by the steam nozzle with the separator outlet are not steam tight. But they are nearly so, and hence any steam which leaks through at these points is wiredrawn in the same manner as though it had passed through the screens. These slight leaks also serve to allow any separated moisture particles to run back into the boiler after being arrested by the screens.

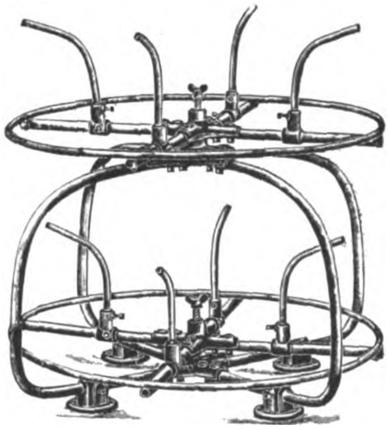


FIG. 2.—ADJUSTABLE REEL.

Of course, condensation will occur in the steam pipe in spite of internal separators, but the higher the quality of the steam at the steam nozzle the more efficient will be the transmission and the less will be the amount of condensation necessary to be taken care of between the boilers and the engines.

TELEPHONE ENGINEERING.

Stringing Outdoor Wires.

BY F. J. DOMMERQUE.

Insulators are not put on the pins until everything is in readiness for stringing the wires. If only one or two, or a few, wires are strung at a time a single reel may do, mounted upon a hand barrow and carried along the line by two men paying out the wire as they go; or the reel may be mounted upon a cart drawn by a horse. Fig. 1 illustrates a reel with adjustable pins which is used to a great extent in Germany and differs from the ordinary reel in being fitted with slots in which the pins slide. The upper cross with the slots turns around a pivot and is provided with rollers which travel upon a ring, to reduce friction. Fig. 2 shows a similar reel of iron manufactured in this country.

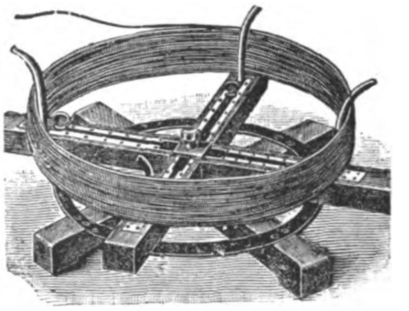
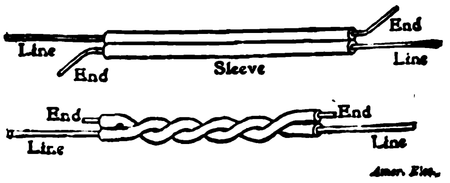


FIG. 1.—ADJUSTABLE REEL.

In unrolling the wire from the reel as the latter is carried along the line, care must be taken that it does not become kinked or twisted around its own axis, as thereby its strength is greatly impaired. When the wire is in place any irregularity in unrolling it may be traced by the wavy appearance that it will have. When one coil of wire is used up, another coil has to be joined to it, of course. Copper wire joints or splices are made with either McIntire or American sleeves, which have been mentioned previously. The ends of the wires to be jointed are pushed through the sleeve, as shown in Fig. 3, and then the sleeve is given five twists, giving the joint the appearance shown in Fig. 4. For twisting, two pairs of splicing clamps with holes fitting the sleeve are used. Iron wire joints are made with iron wire sleeves or with the so-called "Western Union" joint. In this case the wires are first twisted and then the end of one wire wound around the other, as illustrated in Fig. 5.

There is still another splice in use: the so-called "three-wire splice" where a piece of wire from 8 to 12 inches long is placed alongside the two ends of the line wires to be joined, and all three are then clamped in the middle by the tool and twisted like



FIGS. 3 AND 4.—SLEEVE CONNECTION.

an ordinary wire joint, except that there are two ends to wrap around at each end instead of one. This joint is shown in Fig. 6; it is much stronger than the ordinary joint and naturally of better conductivity.

These hand-made joints need soldering; as a flux, resin should be used so as to avoid corrosion in the future. The solder consists best of three parts lead and two parts tin, melted and kept molten in a pot over a soldering furnace; into this pot the joint is dipped. After the joint is soldered, it must cool off slowly and should not be dropped too soon upon damp ground.

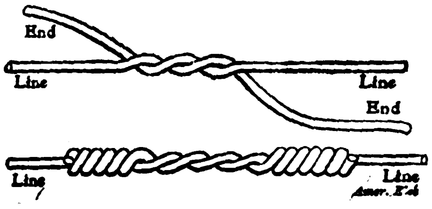


FIG. 5.—ORDINARY SPLICE.

If a large number of wires must be strung at the same time, the cart may be provided with a frame carrying several reels side by side, usually ten, corresponding in number and position to the ten pins on the cross-arm, the reels being mounted so that they can be removed and refilled. Each reel ought to be provided with a brake so that the speed of the reels may be regulated individually; otherwise the wires may become tangled in paying out. The so-called "running board" is also used for stringing a greater number of wires. A number of coils, ten if all the pins on the cross-arm are to be used, are put on reels at the first pole and each one of the wires is threaded through a hole in a board (the running board), the holes having the same spacing as the pins. To the center of the running board a rope is fastened and by means of this rope the board is lifted over the first pole so that the wires rest on the cross-arm; then a team of horses is hitched to the rope, "walking away" with it and thus pulling the wires over the cross-arms. A man stationed on each cross-arm guides the wires over the arm, which is by no means easy.

As soon as the wires are stretched across the arms the men on the poles begin tying them. As a rule the line commences at a cable pole, or if the line is the continuation of another line, at a corner pole, and terminates at an anchor pole; therefore, two ends of the line are "dead-ended." The method of dead-ending is shown in Fig. 7. The end of the wire is pushed through one side of a half-sleeve joint and its free end is then bent around the insulator and pushed through the other side of the half-sleeve; then the sleeve joint is given one and one-half turns, leaving the eye opening two inches. On straight lines the wires are placed on the sides of the insulators toward the pole, except the two wires adjacent to the pole, these being placed on the outer sides of the insulators. On curves and at corners, all wires are placed on the sides of the insulators toward the outside of the curve or corner—the "off" sides.

Before the line wire can be tied it must be given the proper "sag." As is well known, the wire forms between two poles a more or less flat curve, the form of which is mathematically termed a catenary, but can be considered a parabola on account of its flatness. The curvature depends on the tension in the wire. The tension in the deepest point of the curve depends on the weight, on the elasticity of the wire, the temperature, and the distance between the two adjacent poles. With increasing temperature the wire expands, which increases the sag and decreases the tension; contrarywise, a decrease in temperature contracts the wire and decreases the sag, while increasing the tension. The wire elongates with increasing tension and contracts with decreasing tension. The amount of tension put on a wire should not be more than one-half its ultimate strength at the highest temperature and need not be more than one-sixth of its ultimate strength at the lowest temperature.

A table has been calculated giving the tension for the different temperatures at which wires are strung, taking into account the distance between poles and the size of wire, but to regulate the sag of wires by such tables a reliable dynamometer is required. The dynamometer is a strong spring balance and is attached with one end to the insulator. This method is too complicated for the ordinary lineman, though it is technically the correct method. The accompanying table gives the sag in inches required for a certain span at a certain temperature, without necessitating the use of a dynamometer, this table holds good for copper as well as iron wire. The table has been calculated for an ultimate strength of copper or iron of 60,000 pounds to the square inch and an assumed factor of safety of about 3 at a temperature of 10° Fahr.; the table has been used by telegraph and telephone companies to a great extent and is, therefore, sanctioned by practice.

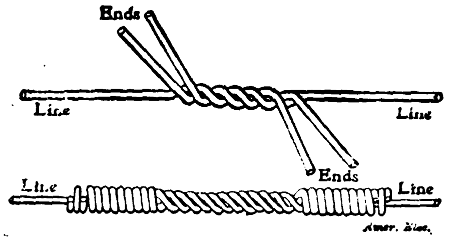


FIG. 6.—THREE-WIRE SPLICE.

TABLE GIVING SAG IN SPANS.

Temperature in degrees Fahr.		Length of span in feet.					
		75	100	115	130	150	200
		Sag in inches.					
Below zero	30	1	2	2½	3⅜	4½	8
	10	1¾	2½	3	3¾	5	9
	10	1½	2⅝	3½	4⅜	5¾	10¼
	30	1¾	3	4	5⅛	6¾	12
	60	2½	4¼	5½	7	9	15⅜
	80	3⅛	5⅜	7	8⅝	11¼	18¾
	100	4⅓	7	9	11	14	22¼

In order to obtain the right sag between poles the men on the poles "sight the wires." The sighting begins at the first pole, of course. There are various methods of measuring off the sag; some linemen sight by the known distances of objects on the pole, as for instance, by the bottom of the glass insulators as being equivalent to two inches, the top of the cross-arms being equivalent to 3½ inches, the bottom of the cross-arms being equivalent to 8 inches, etc. A better method is to provide a rod having at its top end a scale of inches and a slide with a projecting pin arranged to slip up and down this scale. Set the pin at each span for the required sag and have a man set the rod up at the center of the span and adjust its height until the lineman sights the top of the rod in line with the grooves on the insulators; then the wire is pulled up until it touches the pin on the scale. For pulling the wire up the "come-along" is used. In case several wires are put up on the same cross-arm, the sighting can be done from the ground after the first wire is tied. The man goes far enough away from the line so that he can see when the other wires come up to the level of the first one and then gives the signal to tie in. Where the line is running down hill, the man with the rod has to follow the deepest point of the curve in the wire and the wire must be tied in quickly so as to prevent it from slipping through toward the lower pole.

Transpositions.

Whenever more than one telephone circuit is run upon the same pole-line over a great distance, the effects of induction from one circuit upon the others impair the service seriously. In towns and cities pole-lines are hardly ever long enough to be bothered in that respect, but the so-called toll and long-distance lines must be "transposed" to overcome inductive troubles. These transpositions are always made at the poles, using double insulators instead of the ordinary ones and dead-ending one end of the wire at the lower groove and the other end at the upper groove; then a cross-connection is made between the two sides of the circuit. Fig. 8 shows the regular transposition used for two adjacent insu-

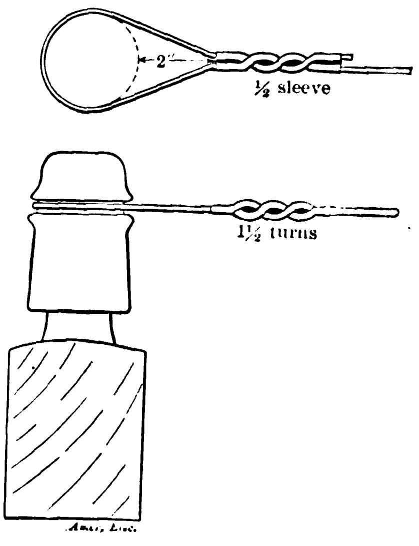
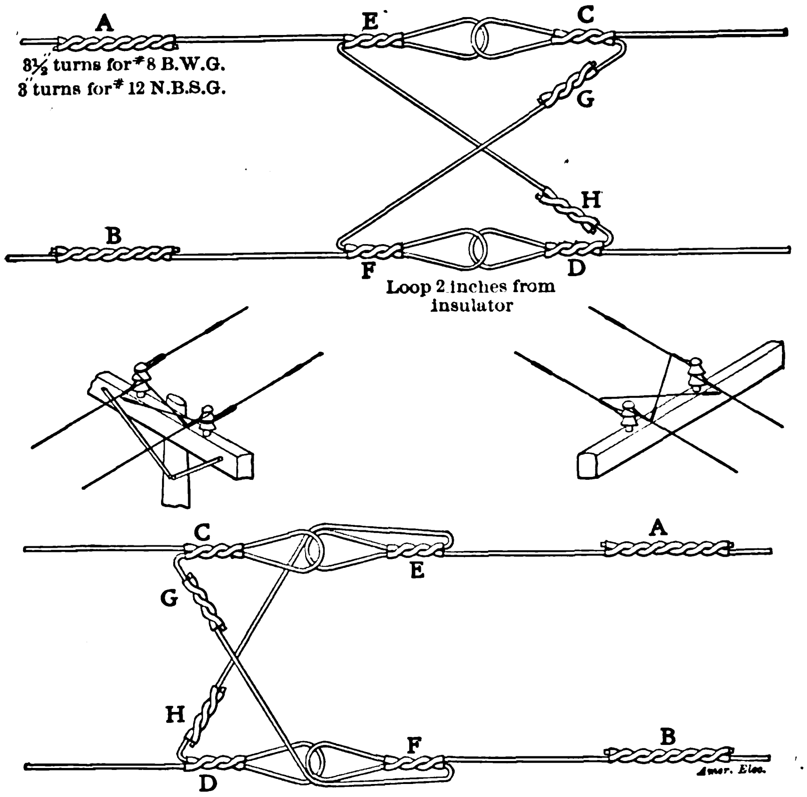


FIG. 7.—METHOD OF DEAD ENDING.

lators on the cross-arm where an unrestricted transposition can be made, and Fig. 9 the pole transposition necessary; the two insulators are located one on each side of the pole. Figs. 10 and 11 illustrate these transpositions with the insulators removed.



FIGS. 8, 9, 10 and 11.—REGULAR AND POLE TRANSPOSITIONS.

The American Telegraph & Telephone Company specifies that these transpositions should be made as follows: Cut the wires on pole side 20 inches from the cross-arm. Slip on the half-sleeves *C* and *D* and dead-end as shown, leaving the ends projecting for sleeves *G* and *H*. Cut in 6 feet of slack on the pole side by means of the standard sleeves *A* and *B*.. Slip the sleeves *E* and *F* on the slack ends and dead-end as shown. Sleeves *G* and *H* are then slipped on, and the transposition completed. Twist all half-sleeves 1½ times. Hold the double connector at the insulator end of sleeves *E* and *F*, and at the wire end of sleeves *G* and *H*, stationary. In transposing pole wires, bring the cross-wire back around the glass as shown.

Fig. 12 shows in plan view the transpositions of ten circuits, five of which are on one cross-arm and the other five on the other cross-arm, the two cross-arms being designated as upper and lower cross-arm respectively. The twenty wires are numbered from 1 to 20, and each of the eighteen transpositions in the diagram is designated by a letter, beginning at the first transposition with *A*; *C* designates the third transposition, but the fourth transposition is designated again by *B* the same as the second transposition, because the fourth transposition takes place between the same wires as the second transposition. For the same reason, the fifth transposition is designated *A* again, and so on. When only one circuit is put up, the wires 5 and 6 are usually taken as the first circuit; the distance from transposition to transposition on this circuit is four times thirteen hundred feet or practically one mile. When the next circuit is added the transpositions occur every half mile, and so on according to the diagram. When the pole-line contains more than two cross-arms, transpose the third, fifth, seventh, etc., cross-arms like the first and transpose the fourth, sixth, eighth, tenth, etc., like the second cross-arm.

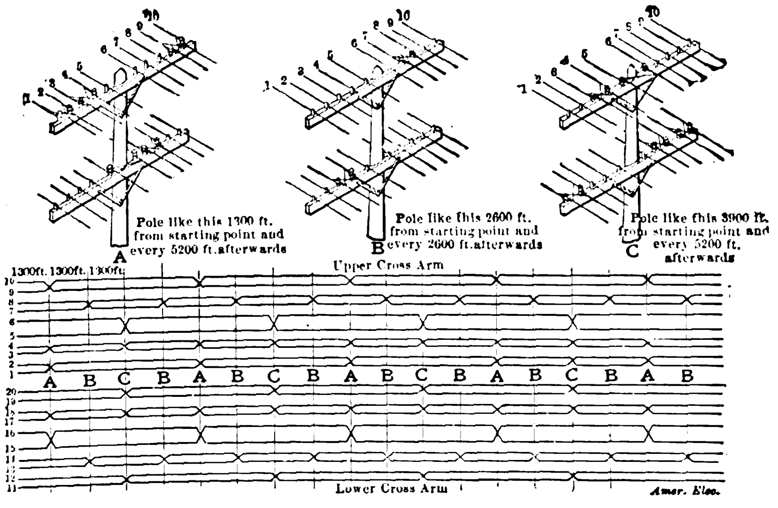

Pole like this 1300 ft. from starting point and every 5200 ft. afterwards
A
Pole like this 2600 ft. from starting point and every 2600 ft. afterwards
B
Pole like this 3900 ft. from starting point and every 5200 ft. afterwards
C
1300ft. 1300ft. 1300ft.
Upper Cross Arm
A B C B A B C B A B C B A B C B A B
Lower Cross Arm
Amer. Elec.

FIG. 12.—TRANSPOSITIONS ON TWENTY WIRE LINES.

Transpositions offer a convenient place where the line can be opened for testing, which is sometimes necessary when the line is found to be noisy. The tester will cut in on the line at each second transposition from the point he is testing with, as this would always be a balance point. In this way, he would soon find out the point where the unbalancing occurs and could clear the trouble by inserting another transposition in the center of the unbalanced section. In doing this, however, care must be taken that the circuit under consideration is not thrown out of balance with respect to the other circuits on the cross-arms.

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LIQUID FUEL.

BY CHARLES L. HUBBARD.

Wishing some time ago for data covering in a general way the subject of liquid fuel, the writer made an examination of quite a large amount of literature on the subject which has been published during the past year, and thinking this might be of interest to others, the substance of it is given herewith in condensed form. Most of the published articles have taken up some special branch in connection with the matter, or have given the result of a single trial coming under this observation. While these are of much value to a person making a careful study of the subject, they are oftentimes somewhat confusing to one who wishes for a general knowledge of the matter without going too much into the details. Various writers differ more or less when dealing with the same points, so that it has been necessary in what follows to give average rather than specific conditions and results.. The principal advantages claimed for oil as a fuel as compared with coal are the absence of soot and ashes, resulting in clean heating surfaces and increased steaming capacity of the boilers; a more even distribution of heat in the combustion chamber, as it is not necessary to open the feed doors to supply fresh fuel; a reduction in the cost of handling, as this is done mechanically or by gravity; absence of dust, ashes and clinkers, and ease of regulating the fires.

The disadvantages urged against oil are danger of explosion under certain conditions if stored in too warm a place; higher cost in many localities, and excessive noise from the burners if not properly constructed and adjusted.

There are two kinds of oil in general use for fuel; one is the crude petroleum as it comes from the wells, and the other is the residuum which is left after the lighter oils have been distilled.

The heat liberated by the combustion of

one pound of petroleum will vary from about 17,000 to 20,000 heat units as against 12,000 to 14,000 for an equal weight of coal, making, on an average, the heating value of a pound of petroleum approximately equal to 1½ pounds of coal. In actual practice the ratio is found to be somewhat greater; under ordinary conditions from 3½ to 4½ barrels (42 gallons per barrel of oil are considered equivalent to a ton of coal (2,000 lbs.). Taking this as a basis the relative costs of the two fuels for any given locality can be approximately computed, due allowance being made for the reduction of labor in the case of oil.

Oil fuel does not burn as a liquid but must first be reduced to a vapor. After this change has taken place it is then mixed with the right proportion of air and burned in a chamber kept at a suitable temperature. Means for vaporizing the oil, for insuring an adequate supply of air, and for producing an intimate mixture within a chamber kept at a suitable temperature must therefore form the foundation of all methods of oil burnings. There are many different forms of burners on the market, but they may be divided into three general classes as follows: Mechanical spray burners in which the oil is forced under high pressure through a nozzle of such form as to break it up into a fine spray and thus render it more readily inflammable; air burners, in the use of which the liquid is held in suspension and driven into the furnace by means of a jet of compressed air; steam jet burners, in which the oil is injected in the form of a spray by means of a jet of steam, and allowing the right amount of air to mix with it, partly by suction through an opening in the burner and partly by way of openings from the ash pit into the furnace.

Vapor burners are also used when the oil is first volatilized in a separate chamber and then burned in the furnace in the form of gas. In the Korting mechanical spray burner the oil is first heated to a temperature of about 270° Fahr., and then forced under a pressure of about 50 pounds per square inch through a nozzle having a small orifice in which is an adjustable spindle spirally grooved. The rotary motion thus given to the oil causes it to break into a spray from the effects of centrifugal force as soon as it leaves the nozzle. In another form of burner the fuel passes through a minute orifice and is divided into a fine spray by striking against a cutter placed at a short distance in front of the orifice.

Compressed air and steam are used in oil burners in very much the same manner. When air is used it should first be heated to a high temperature by passing through a fire brick duct built into the furnace or combustion chamber.

In the Williams burner, oil and steam enter through separate openings and meet at the end of a conical spindle placed in the centre of the steam delivery tube. A third opening just beyond the spindle admits air from the back of the furnace through a fire brick duct built on top of the grate. Both the steam and the oil inlets are provided with valves for regulating the flow of each to the burner, from which a mixture of steam, oil and heated air are blown into the furnace. In some other forms of burner the oil is heated in the burner itself by passing it through passages surrounded by steam.

Burners for using steam are preferable for large furnaces with much brickwork, as they spread the flame more and thus fill the entire furnace. Air burners concentrate the flame at the point of contact and are very destructive to plates and brickwork. Single burners are made for all sizes of boiler furnaces up to 300 horse-power or more, but a number of smaller burners are found to use less fuel per horse-power than a single large one. One burner for each 50 or 75 horse-power has been found to give the most satisfactory results under ordinary conditions. A burner placed in the center of each fire door is the arrangement usually employed.

The construction of the furnace varies somewhat with the kind of boiler and type of burner used. The common method is to spray the oil against brickwork and along the grates, which should be covered with fire brick. This keeps the brickwork in an incandescent state and assists in the combustion. The covering for the grates may consist of broken fire brick laid in a loose bed so as to admit plenty of air. The grates should be of good length with a bridge wall placed at the rear for the flames to strike against. Air may be admitted through the ash pit doors in the usual way.

Another method is to cover the grates with asbestos board on top of which is loosely placed a layer of fire brick on the flat and the whole plastered over with fire clay.

Uncovered spaces of about 70 square inches should be left under each 50 horse-power burner for admitting air from the ash pit.

A "cascade" or "spatter wall" built of fire brick on edge with narrow spaces between them is placed in front of the bridge wall, and the burners are so aimed that the flame will strike the cascade wall about one third the way up from the bottom.

Some types of burners can be bolted directly to the grate bars without change in the furnace construction. Whatever kind of burner is used it should be so arranged that the flame will not be thrown directly against the boiler plates, for if this is done they will soon become overheated and badly injured.

The best way of storing fuel oil is in an underground tank made of boiler iron and placed outside of the boiler room if possible. The oil is either pumped to the burners or forced by means of steam or air pressure admitted to the upper part of the storage tank. When steam is used for this purpose it also serves to warm the oil so it will flow more freely through the piping at the burners. If a pump is employed, a steam coil is placed in the tank and supplied either with live steam or with exhaust from the pump. In some systems the oil is warmed and purified by admitting hot water from the boilers into the lower part of the storage tank. In order to obtain the best results, the oil should be supplied to the burner at a constant pressure. This is commonly done in one of two ways; a relief valve may be placed in the delivery pipe from the pump which will discharge back into the tank when the pressure reaches a given point, or the oil may be pumped to a stand pipe from which it flows under a constant head to the burners. When a stand pipe is used, the insurance companies require the use of an automatic valve which will drain the oil from the stand pipe when the steam pressure drops below a given point. This is done to prevent flooding the furnace with oil when there is not sufficient pressure to atomize it.

If the oil commonly used for fuel is heated much above 140°, gases will be formed which, while not explosive by themselves, will ignite when mixed with air and cause violent explosions. Gases are likely to be formed by overheating, either by the sun or by nearness to the furnace; again, if air is forced through the oil it will become saturated with inflammable products and form an explosive mixture; gases will be formed also if the oil is violently churned or agitated, as by passing it continuously through a pump by connecting the discharge from a relief valve directly with the pump suction. The oil itself is not easily inflammable, and a lighted match or red hot coal may be dropped into it without its catching fire. With ordinary precautions the danger is very slight and when used in connection with stationary boilers need not be seriously considered. Some engineers recommend the use of a residuum from which the lighter products have been distilled to such a degree that the flash point is raised to a comparatively high temperature, thus practically eliminating the factor of danger under any rational conditions.

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Combustion in Boilers.—Most steam engineering specialists hold the opinion that with bituminous coal and hand firing the combustion in a boiler furnace is incomplete unless provision is made, by either the arrangement of the boiler or the regulation of the system of firing, to introduce a sufficient amount of air into the mass of burning gases. There have been many demonstrations of the favorable result of supplying air properly distributed through the gases, in the case of return tubular boilers. It seems to make little difference how the air is admitted, whether it is hot or cold, or whether the device employed for admission is simple or complicated, the efficiency of combustion is improved and there is an increase in the economy of the boiler. For example the efficiency of a 60-inch return tubular boiler was increased no less than 8 per cent by fitting it with appliances for introducing air at the bridge wall, the supply being first carried through pipes extending back and forth at the point of its discharge. In another case there was a gain of 9 per cent produced by introducing air by means of a checkerwork in the combustion chamber.—*Exchange.*

20th Convention of the American Institute of Electrical Engineers

By far the most successful meeting in the history of the American Institute of Electrical Engineers was convened at Niagara Falls, New York, on June 29, remaining in session until July 3. Through the courtesy of the Natural Food Company, the sessions, excepting that of Monday evening, were held in an auditorium in the works of that company. Exclusive of a number of written discussions of considerable length, almost forty papers were presented, abstracts of many of which follow.

The Storage Battery in Sub-Stations.

In a lengthy paper on this subject, Messrs. W. E. Goldsborough and P. E. Fansler give a complete report of a test made in 1902 on the large interurban system, with nine sub-stations, of the Union Traction Company in Indiana. At the time of the test the company operated over 160 miles of track. At the main station the generators give alternating current at 400 volts. This is stepped up to 16,000 and transmitted to the sub-stations, where it is stepped down to 330 volts. Synchronous converters then change the current to 550 volts direct current, which is used on the trolley system. One sub-station contains three 250-kw. converters, a 20-kw. booster and a battery of 264 chloride cells, giving 400 amperes for one hour and 100 amperes for 8 hours. Five other sub-stations are equipped each with a 250-kw. converter and a battery of 264 cells, giving 160 amperes, for one hour and 40 amperes for 8 hours, and an 8-kw. booster. The remaining three sub-stations contain each two 250-kw. converters, one 16-kw. booster and a battery of 264 cells, giving 320 amperes for one hour and 80 amperes for 8 hours. The all-day efficiency of the high-tension distribution from the low-tension bus-bars in the generating station to the direct-current terminals of the rotaries was found to be 73½ per cent.

In each sub-station the booster is so connected in the battery circuit as to automatically adjust the battery voltage to the demand on the sub-station; in other words, the battery charges and discharges automatically, feeding out to the line when the demand is above a given amount, and being charged by the rotaries when the demand falls below that amount. The potential at which the battery will float on the system or the demand on the system corresponding to which the battery is inactive, can be adjusted at any point by the switchboard attendant.

In a preliminary test the "efficiency of equalization" in one sub-station was determined. This is defined as the ratio of that portion of the rotary load curve that is above the average load curve to that portion of the line load curve which is above the average load curve. In the sub-station tested this efficiency of equalization of the battery was found to be only 11.9 per cent., which is rather low. This indicated that the adjustment in this sub-station was somewhat faulty.

The results of the main tests of the batteries are given in a great many diagrams. Over four-hour periods, the highest discharge performance in one sub-station was that the battery developed 39 per cent of its discharge capacity; at three other sub-stations the batteries never developed more than 28 per cent of their discharge capacity over a four-hour period, and at another station it did not exceed 14 per cent. These figures show that, as gauged by the average demand on the sub-stations, the batteries are amply large enough to take care of variation in the demands made on the sub-stations by the trains. It is believed, however—and this has a bearing on the result mentioned above obtained in the special preliminary test—that the motors driving the booster armature were not heavy enough to hold up to the momentary demands which rapid changes in the load bring upon the sub-stations. Heavy balance wheels placed on the booster shafts would cause the batteries to show a very much higher charge and discharge kilowatt performance during four-hour intervals, and they would serve to reduce the fluctuations reflected through the sub-stations from the trains to the central station. An improvement in the variations of the load coming on the central station will in time increase the economy of the generating station. This is a point to which attention should be given in laying out sub-stations for work of this character.

The average commercial performance of five batteries during the three days of the test was found to be 74, 88, 96, 76 and 112 per cent. Taking the ratio of the total discharge of all the batteries to the total charge of all the batteries in these five sub-stations, an aggregate efficiency of 95 per cent for the batteries in the sub-station is obtained; or if the efficiency values are averaged as obtained for the five sub-stations, the average efficiency of the batteries during the time is 89 per cent. These values are high, and yet they continue so for relatively long periods without any special indications of deterioration in the batteries.

Mr. Stott stated that in the Manhattan sub-stations the rotaries have worked under 68 per cent overload. He thought a test would be interesting during which the sub-stations were worked one week with storage batteries and one week without storage batteries. Prof. Goldsborough said that in the test he described, it was attempted to cut the storage batteries out of some of the sub-stations, but it was found rather disastrous with respect to the main stations, the engineers in charge not desiring to submit the generating plant to the additional strain. The advantages of the storage battery begins at the generator, since the engines will operate more efficiently when the load on them is maintained constant. Moreover, the current in the high-tension lines and through the transformers and rotaries will be much more constant, and consequently the copper loss will be less. The matter of a storage battery equipment properly adjusted to its work is thus an important element.

Y or Delta Connection of Transformers,

was the subject of a paper by Mr. F. O. Blackwell, who discussed the comparative advantages and disadvantages of the two alternative methods of connecting transformers to a three-phase system. The comparison is made under the following headings: Size of transformers required; grounding the neutral; unstable neutral; rise of potential. The selection of Y and delta connection of transformers for long-distance transmission should only be determined after a careful consideration of the conditions in each case. There is little choice between Y and delta without a grounded neutral. In small installations, the cheaper cost of transformers for Y with a grounded neutral will be a determining factor. Larger plants will be guided by the greater importance of giving uninterrupted service and will not employ a grounded neutral unless demanded on the score of safety. Where the amount of power is great and the system extensive, delta connection will be generally preferred on account of its avoiding the possibility of rises of potential from any cause. Many plants can have advantageously a mixed system with both Y and delta transformers, each installation of transformers being considered by itself.

Grounded and Underground Transmission Circuits.

Mr. J. S. Peck discussed the problem of grounding a transmission system with reference to Mr. Blackwell's paper. By the grounding of the neutral point it is sought to limit the strain from line wires to ground and to limit the strain between high-tension and low-tension windings of the transformers, also between the high-tension windings and iron case. The author discusses in detail with the aid of diagrams the effect of grounding on the various possible polyphase systems and sums up his results in a long table. In many cases the grounding of the neutral points of a transmission system limits the voltage strain to ground and the voltage which may be obtained across any transformer, and in such cases grounding would seem advisable. This is notable in the case of the star system with grounds on transformer and generator neutrals. There is, however, the danger arising from this grounding that in case of trouble on the circuits current may flow through the ground to the neutral; in thus flowing it will naturally take the path of least resistance, so that if telephone or telegraph lines, which have normally low resistance to ground, parallel the transmission circuit, the current will flow along these wires, often with disastrous results to the circuits. Two cases of trouble are particularly liable to occur: First, where the neutral points of the high-tension windings of raising and lowering transformers are grounded, the opening of one or two of the three transmission wires will cause currents to flow through the ground; second, a high-resistance ground on a transmission wire will partially short-circuit a transformer and cause current to flow through the ground to the neutral. Some plants have been able to operate satisfactorily with grounded neutrals; with others this grounding has caused great disturbance on telephone circuits, and in one plant it is reported that the blowing of a fuse on one of the high-tension wires put out of service the telephone systems in "ten counties." Thus, while grounding of neutrals may be permissible in certain localities, it may not be allowable in others; and in laying out a plant it would seem to be advisable so to arrange the apparatus that it may be safely operated without grounding the neutrals. An examination of the tables given by the author indicates that the delta system is the one giving the minimum chance of trouble. Under certain conditions, however, the star and star-delta systems will give satisfactory service.

In the discussions of the papers of Mr. Blackwell and Mr. Peck, President Scott called attention to the fact that the question of grounding or not grounding the neutral was not at all settled yet. Diametrically opposite opinions are held by practical engineers concerning it. Mr. Haywood, who has operated his 17,000-volt lines without grounds, said his experience was that one may have a short-circuit on one wire and with the wire down one could still keep running. Still, he was of the opinion that with very high voltages it was better to ground the neutral and to keep them grounded everywhere. Mr. Gerry believed that it was possible to get equally good results by the use of either delta or Y connection on a transmission line. It was possible so to connect the transformers in star that one transformer could not be cut out without practically all three being cut out at the same time, and when transformers are connected in that way, with the neutral grounded, it should always be done. The star connections of the transformer should be permanent, so that one transformer cannot be cut loose from the other two, and a reverse can be arranged with reverse apparatus. It was questionable, he said, whether the star connection was desirable, although there was a very small advantage gained in the design of the transformer. Mr. Nunn described the troubles which his company had experienced. When operating their 40,000-volt system, the current at one time jumped 8 feet from the conductor to the steel framework of the roof. He knew the fact but not the conditions which caused it, and after an experience of five or six years with 40,000-volt work he concluded that there was considerable about it he did not know and could not even guess at. Mr. Junkersfeld referred to moderately high-voltage transmission lines, such as are used in large cities. In Chicago they have been operating a four-wire, three-phase, 60-cycle overhead system, with a grounded neutral, for about three years. The generators are star-connected and the common point is connected to the ground. They ground in the station only, and do not ground any other point of the primary system. The neutral of the secondaries is also grounded. In their underground system, which is operated at 9000 volts and 25 cycles, they likewise operate now with the grounded neutral. For the first four or five years, while the voltage was only 4500, they had step-up transformers with delta connections. The next step was to double the voltage and install line voltage generators, which are operated with the grounded neutral with very satisfactory results. He emphasized the necessity of doing away with single-pole fuses and switches. With the increase in the number of transformers, he had come to the conclusion that the advantage of having delta-connected transformers, in order to be able to cut out one of the bank and operate with two, was not very great. His company had now changed over to Y connection and was installing three-phase transformers, the idea being that with these accidents occur very rarely, and when they do occur, one can afford to have a whole unit shut down. Mr. Gerry held there was some advantage in using a delta-connected system since by the use of single-phase switches the excessive potentials mentioned by Mr. Peck are avoided. When satisfactory and reliable switches can be obtained for opening all three legs of a circuit the system might be changed to star connection, but whether this is desirable or not is another question. Mr. Woodbridge, in a written communication, took up the special case of high-tension power distributed for the operation of rotary converters. In distributions of this kind, the secondary voltage of the step-down transformer is so low that there is no advantage in a Y connection of the secondary coils. On the contrary, this is disadvantageous. For this reason, a delta connection of the secondary windings is to be preferred for three-phase converters. With the primary winding connected Y and the secondaries delta, in operating the synchronous machinery, there is no instability of the neutral. After a detailed discussion of the various points which must be taken into consideration, he reaches the conclusion that systems having a working pressure between wires of over 25,000 or 30,000 volts should have the high-tension windings of their step-up and step-down transformers Y-connected with the neutrals grounded. Dr. Louis Bell, in a written communication, concurred with Mr. Blackwell's conclusions. The Y systems which are valuable in saving copper entail some additional care. In practice he has found that mixed delta and Y converters are desirable and tend to steady regulation. He is a firm believer in grounded neutrals as a safety measure, but maintains that sources of accidental grounds should be followed rigorously and carefully eliminated.

Methods of Bringing High Tension Conductors Into Buildings.

In a paper having this title, Mr. C. E. Skinner deals with the general requirements for bringing high-tension conductors into buildings. The requirements which must be met are the maintenance of proper insulation of the circuit, the prevention of the entrance of rain, snow, cold air and dust, the proper mechanical fastening of the line wire, reliability and simplicity of construction. In general, wires are best brought through the walls of the buildings. The simplest form of construction consists merely of an opening in the wall sufficiently large to allow the proper air insulation between the wire and the wall, this opening being suitably protected from rain either by means of a large pipe set in the wall, sloping outward or by a sufficient extension of the roof above, or both. The wire must be at a sufficient distance from the pipe. The pipe should always be considered as "ground." The cross arms holding the wire inside and outside of the building should be sufficiently near and so braced that the wire will remain central in the pipe. With potentials of 15,000 volts or lower a disc of glass or other fire-proof insulating material is placed over the wire at the inner end of the pipe. The tube must be sufficiently large so that the surface insulation over the insulating disc used will be ample to prevent trouble under the worst conditions. When there is any danger of condensation of moisture, due to differences of temperature inside and outside of the building two discs a little distance apart should be used. Their surface insulation should never be less than that of the line insulators. For voltages above 15,000 volts, a long insulating tube of small diameter and very heavy wall may be placed over the wire and passed through a slag of insulation set in the wall of the building, the whole being protected from driving rain by an extension of the roof. The insulating tube should slope outward in all cases. Some form of drip point should be provided on the wire just outside the end of the tube. The insulation slab holding the tube should be large enough to prevent actual break-down even though the tube is broken. Both tube and slab should be of fire-proof material. This form of construction has been successfully used for potentials as high as 50,000 to 60,000 volts.

In the discussion of this paper, Mr. Floy in a communication considered that the use of glass plates or of conductors insulated for a portion of their length, as in the scheme advocated by Mr. Skinner for bringing the wires into a station, was objectionable because of the constant menace of leakage and grounding of the system through the wall of the building. He believed that there was nothing quite equal to a plain but generous hole in the wall through which the wire, rigidly supported, may pass. Mr. O. H. Ensign, chief engineer of the Edison Company, Los Angeles, Cal., did not believe that any sort of glass plate insulation would do. He uses for 30,000 volts plain open 12-in. sewer pipe. Mr. A. L. Mudge, in a communication, suggested that the terra-cotta pipe mentioned in Mr. Skinner's paper should be closed at the outer end to prevent birds and insects getting into and building nests in the pipe. Mr. F. C. Pierce did not believe in allowing the wall of the building to take the strain of the line, and suggested that the last poles of the line should be guyed. Dr. Louis Bell considered that the mania for compactness had been responsible for more trouble in high-voltage systems than any other one cause. Wire towers for high-potential lines should be avoided. The high-voltage wires and all their connections should be so placed that their whole arrangement would be evident from a cursory glance. Mr. J. Harisberger stated that the Snoqualmie Power Company adopted at the very beginning the second arrangement suggested in Mr. Skinner's paper, and with all its high-tension troubles, has yet to experience its first trouble with this style of construction for entering buildings. In some of the buildings, where the wires enter with the first construction suggested by Mr. Skinner, in every case where the high-tension lines became grounded for one reason or another, there was a discharge across the plate glass to the terra-cotta pipe. Mr. R. F. Hayward described some methods used in Utah, where on account of the climatic conditions wires are kept much farther apart than in the East. Good glass tubes had proven satisfactory, but porcelain tubes were better. On 16,000-volt circuits he used a piece of 12-in. plate glass with a ¾-in. hole drilled in it with wires passing through, and has never had the slightest trouble. He considered that the most important thing in outlets was to provide large spaces and not to cumber the outside of the building with any extra structure. Mr. V. G. Converse preferred porcelain tubes to glass, and suggested the use of a rain shed. This proposal was concurred in by P. H. Thomas, who also suggested mounting the true high insulating inlet on an insulating panel. Mr. P. M. Lincoln recommended that the end strain of the line should be taken up by a strain insulator inside.

A paper by Mr. Henry W. Fisher entitled

Electric Cables for High-Voltage Service

gave some notes on the manufacture of cables. Since paper-insulated cables have been improved, some engineers prefer paper to rubber, the life of paper cables being assumed to be longer than that of rubber cables. On the other hand, the ability of a rubber-insulated cable to withstand high voltages depends upon the ingredients entering into the composition of the rubber compound. The dielectric strength to resist electric pressure becomes greater within certain limits with increased percentages of pure Para or other high-grade rubber, and there is good reason for believing that when lead-covered cables are employed the life of rubber-insulated cables is lengthened with increased percentages of such rubber. In the manufacture of paper-insulated cables for high voltages, great care has to be exercised in selecting the right kind and quality of material, and also in the methods of construction and impregnation of the paper with the insulating compound. Cables saturated with oily compound can better be handled without injury to the dielectric, and also resist better high voltages. The use of oily compound is, however, accompanied with lower insulation resistance, and consequently many engineers who think they are adopting the best practice by specifying several hundred megohms per mile, are in reality inviting bids on an undesirable type of cable.

The carrying capacity of cables as frequently recommended is entirely too great when many cables are in the same duct system. In this case the middle and top one, although carrying normal currents, are apt to become very warm. Under no circumstances should the temperature of the conductor be allowed to reach 90° C.

The Operation and Maintenance of High Tension Underground Systems.

A paper by Mr. Philip Torchio gave some notes on moderately high-tension underground systems as installed in large cities in the last few years. Concerning independent vs. parallel operation of feeders at sub-stations, he remarked that independent operation has in most cases the disadvantage of not allowing the full use of the copper investment at light loads; but has the following advantages: The short-circuit current fed back from the sub-station bus-bars into a faulty feeder is limited by the reactance of at least two sets of transforming apparatus, which will materially help the final clearing of the short circuit. Further in rotary-converter sub-stations the independent groups of transforming apparatus can be fed from different bus-bars or from different generating stations, thereby increasing the reliability of service. The author made some brief remarks on testing of cables and gives in a table the record of all cable faults of a New York company for a period of five years, the voltage of operation being 6000; of the 9 faults manifested there were 5 due to extraneous mechanical causes and 4 to defective installation.

Ground detectors with annunciator relay and drop-signal are considered as desirable features of a high-tension switchboard equipment. Grounding of the neutral of high-tension generators has apparently given satisfaction wherever it has been tried; the objection to the heavy short-circuit current from one leg to ground has been overcome by the suggestion of grounding through a non-inductive resistance, thereby limiting the short-circuit current to a predetermined amount. It seems impossible always to guard against the appearance of high voltages due to sudden change of load, grounds, short-circuits, etc., and, especially in the latter case, spark arresters will greatly increase the safety. These devices are preferably connected delta on systems without grounded neutral and installed at the generator end as well as sub-station end of every cable and at every other place where the cable is looped into a sub-station or joins an overhead line.

The Use of Automatic Means for Disconnecting Disabled Apparatus

was the subject of a paper by Mr. H. G. Stott, in which he gave some notes on this subject, dividing it into three sections: generating apparatus, transmission apparatus, receiving apparatus. He states as a general proposition that no overload device should be used in the generating plant to disconnect disabled apparatus. On each generator a suitable circuit-breaker should be installed which will operate only when the direction of flow of energy through it is reversed. As an additional precaution in large plants, a second reverse-current relay should be installed which will merely light up a letter or number in front of the operator, so that in the event of the failure of the first automatic device the faulty machine may be quickly disconnected by hand. These reverse-current relays should have a time element and current-limit attachment, which should be set for not less than three seconds, so that a slight reverse current, or one of momentary duration, such as is liable to occur at the moment of paralleling, will not operate the circuit-breaker.

For transmission lines the author recommends to run the feeders entirely separate at the receiving end, only putting the direct-current end of rotaries in multiple; or in cases when low-tension alternating current (2000 volts or less) is supplied, putting the secondaries in multiple. If under these conditions, reverse-current relays are installed at the receiving end of the feeders, they will operate very satisfactorily, as the reactance of the rotaries and transformers will be sufficient to limit the reverse current in the faulty cable, thus allowing the reverse-current relays to operate, as there has been no serious fall of potential. The greater the number of feeders between the generating station and the sub-station, the better this method becomes.

The three papers by Messrs. Fisher, Torchio and Stott were discussed together. Mr. W. C. Carlton contributed a written discussion of Mr. Torchio's paper. The experience of the Chicago Edison Company with its high-tension, three-phase cables has been similar to that of the New York company, mentioned by Mr. Torchio. At present they are operating about 45 miles of three-conductor cable at 9000 volts. The first of these cables was installed about five years ago. The voltage used at first was 4500, but about a year and a half ago it was changed to 9000. There have been seven cases of trouble on these cables; four were caused by mechanical injuries to cables in manholes; one by a burn-out on an adjacent cable; one by a defective joint and one by electrolysis causing a hole to be made in the lead sheath of the cable. With the exception of the defective joint, none of these troubles would have been avoided by using high-pressure tests in the cables. The neutral points of the high-tension generators are grounded direct, no resistance being used to limit the flow of current. Two of the cases of trouble, one due to mechanical injury and one to electrolysis, resulted in one conductor of the cable burning to ground, the other two being left in good condition. Very little damage was done, but he believes that if they had been operating without a grounded neutral, the chance would have been greater for more serious trouble, owing to the displacement of the neutral that would have occurred.

Mr. W. P. Wells contributed a written discussion of Mr. Stott's paper. He states that his recent experience with 6600-volt, revolving-field apparatus in central station practice, has convinced him that automatic disconnecting devices are not necessary in order to insure reliable operation of the system to which current is supplied, and that capable operators with good judgment can handle any cases that may arise. During the two years that his station has been in operation it has always been the practice to run the high-tension feeders on what Mr. Stott refers to as the safest plan, i. e., entirely separate at the receiving end, only putting the direct-current ends of the rotaries in multiple. But as practically all the sub-stations are equipped with large storage batteries, which are also in multiple with the rotaries, it has been found best to operate without reverse-current relays, but depend on the operator in the sub-station opening the circuit-breakers when necessary. On the entire system there are in use no automatic disconnecting devices except those operated by time overload relays on the feeders in the generating station and by a centrifugal speed limit device on the rotaries in the sub-station.

Mr. Eglin said that with the growth of the size of generating stations and with all the feeders run in parallel on a large generating station, some means must be provided for limiting the amount of energy that can be put into any short circuit of a high-tension cable. Their practice has been to subdivide the feeders at the sub-stations not being tied together there. Their operation has been very successful.

Mr. Mailloux said that in many cases automatic devices are undesirable, and referred to the experience which he had with isolated plants in large hotels, where they depend on the operators entirely; the principal thing in such a hotel is to avoid a panic.

Mr. Mershon and Mr. Mailloux asked several questions, to which Mr. Wells replied. It is the practice of the New York company, mentioned in Mr. Torchio's paper, not to make any over-voltage tests on cables, or, in fact, on any electrical apparatus. Cables and apparatus are thoroughly tested before being put into service. A test of a light over-voltage, or 20 or 30 per cent, is enough to determine whether the work has been properly done or not.

Mr. Stott said that it is the practice of his company to make a 30-minute test at 100 per cent over-voltage. They have found that a joint which is comparatively poor will stand up as long as 18 minutes and then break down. They have in operation over 120 miles of 11,000-volt, three-phase underground cable. Out of that 120 miles they have had only one fault in the cable at all. All the others were due to inferior work in the joints. Since they went into operation 20 months ago, they have had a total of four break-downs while operating. He believes that a great deal of the underground troubles which have occurred were not due to faults in the insulation, but to faults in the lead sheath, stray currents from other properties passing through the same. They have now decided to re-instate the lead sheaths of their cables all the way through in the manholes. The conduits are very good insulators themselves.

Mr. Fisher gave an account of cable tests recently made at Niagara Falls. He stated that cables are now working at 22,000 volts in this country, being guaranteed for that voltage. A communicated discussion by Mr. E. P. Burch dealt with the very successful operation of two 12,000-volt, three phase cables, of 9.5 and 7 miles length respectively, in Minneapolis. Most cable faults are due either to mechanical injuries or to chemical deterioration of the sheath from electrolysis; in both cases moisture finally works through the paper insulation. Mr. R. S. Kelsch contributed a written discussion on the use of automatic means for disconnecting disabled apparatus. Reverse-current relays should be set to operate at 5 per cent reverse current.

Some of the transmission lines in this country have installed upon them, as a protection against lightning, one or more wires strung parallel to the power wires and grounded at intervals. A difference of opinion existing among electrical engineers as to the efficiency of this device, Mr. R. D. Mershon in a paper entitled

A Grounded Wire as a Protection Against Lightning,

discussed the problem of its advisability. He gave the theory of the subject and calculated the shielding action of the grounded wires for a special numerical case. If each wire of a transmission line 20,000 feet in length, the conductors of which consist of No. 00 wire, has stretched parallel to it and at a distance of 12 inches a grounded wire equal in size to the line wire, the potential of the line wire due to a charged cloud could not rise to exceed 30 per cent of the value to which it would rise if the grounded wire were not present. This is given only as a rough example to show the magnitude of the effect of the grounded wires. The author referred briefly to the material and dimensions of ground wires and to their method of installation, and gave some results obtained in practice in various plants. In one plant, as a result of a number of years of operation, those in charge felt that the grounded wires furnished a reliable and effective protection against lightning. In some of the other plants it was thought that the grounded wires furnished more or less protection, but the exact amount was doubtful. In still other plants, the grounded wires were held to be of no value whatever and considered a nuisance and menace because of their liability to break and fall across the power wires. In some of the cases of doubtful success, or failure, the trouble may have been due to poor grounds or to the wires not having been grounded frequently enough, as in some of these cases the wires were not grounded at every pole. In all of the doubtful cases lightning arresters, which were installed in addition to the grounded wires, received more or less discharges during thunder storms.

In the discussion of Mr. R. D. Mershon's paper, Mr. R. S. Kelsch gave an account of a careful record undertaken in Montreal, when a great many light and power wires of a company were constructed below the wires of other companies; it was found that the greatest amount of trouble, such as transformer burn-outs, etc., caused by lightning, occurred on the circuits that were built under the lines of other companies.

Dr. Perrine discussed the use of barbed wires for grounding. When a cloud has discharged in the neighborhood of a line, and the line and its accompanying guard wire have reached a stationary condition, the points on the grounded wire tend to aid the release of the charge. The trouble is, however, that in practical operation the barbs form points of mechanical injury, as the wire may be twisted and kinked around the barb.

Mr. C. O. Mailloux referred to a three-conductor line in Arizona, 25 miles long, with only three lightning arresters, one at the transmitting end, one at the receiving end, and the third at a second power plant about 8 miles from the receiving end. This line was started last fall and has worked without interruption; although there were many lightning storms, they never had any trouble from lightning. There were discharges over the lightning arresters, but the operation of the line was never interfered with.

Mr. A. J. Wurts looks on the entire situation as the cloud and the earth forming the two terminals of a hugh static machine. He considers the lines over the earth's surface, electric lines, grounded lines, railroad rails, gas pipes, water pipes, all a part of the one terminal of the machine. He does not believe that a grounded wire in the nighborhood of an electric line will materially protect that line; they will all discharge.

Dr. Perrine pointed out that there are several things to protect against. One is the gradual charge and discharge of the line due to conditions of the atmosphere. The line may gradually acquire a charge from the wind blowing over the line when there is no lightning in the neighborhood; it is against this form of trouble that the guard wire is intended to guard. On the other hand, it is not of any great advantage where there are lightning discharges of severe character.

Dr. Kennelly referred to the long years of experience on this question in the protection of telegraph and telephone lines; among telegraph men it has always been a popular impression, derived from long experience, that the presence of other wires protects the neighboring wires against direct lightning effects. The tendency in a working wire is to carry the earth up over that wire or in the vicinity of that wire and to produce partially that effect which a completely bedded wire produces more thoroughly. If there were enough parallel wires above and around a working wire, they would carry immunity to the latter. Whether it is worth while to do so is a very important question. When some years ago he collected information of this character from the representatives of local stations, he found the evidence to be in favor of protection by means of a guard wire.

Mr. F. S. Woodward referred to a case in which barbed wires had been used and remained in good condition for about two years; at the end of that time they broke and there were a number of short circuits owing to the wire falling over the line. On this same line there were some lightning arresters and an investigation of them at regular intervals showed that they very frequently acted, so that the barbed wires themselves did not prevent the lightning stroke from striking the line wire.

Mr. Rushmore referred to the effect on a transmission line, due to differences in altitude between different parts of the line. This effect is evidenced by injury to the insulation at the lower altitude. He referred to a case in which one part of the line is about 7500 feet above sea level and the other part about half that altitude; the insulation remains good on the higher part and does not hold up at the lower part. Guard wires may protect the line against this effect.

Mr. John F. Kelley believes that the main protective effort of the grounded wire is not against lightning discharges, but principally against the ordinary atmospheric electricity. He referred to troubles due to the latter, experienced on an old telegraph line. The most important point in Mr. Mershon's theory is that the wire should be equally effective if placed below the line, as if placed above. The great danger heretofore has been that it was above and in breaking would fall on the transmission wires. He believes that there may be some protective effect from the grounded wire, but it does not pay for the complications.

Mr. Hayward stated that the Committee on High-Tension Transmission has sent word to every operating engineer, asking that every one of their engineers be made an observer; in the case of a breakdown from lightning, the engineer is to go right to the spot as if it were a fire, and collect all the evidence. In this way it is hoped that in a year or two a large amount of exact data will be collected. He believes that the locality has much to do with the nature of the discharges. He thinks that overhead grounded wires, such as telegraph and telephone wires, are a protection; they have never lost a transformer in their business section, which is the most thickly covered with other wires; but they are not a complete protection by any means. If one would absolutely surround the transmission wires with a grounded network, they would be protected, but this method is absolutely impracticable. The transmission line must be easily accessible. They have made careful records of their troubles from lightning; their troubles always come at the moment when the lightning discharges. Troubles due to the raising of the potential of the line when there is a dust storm, or wind storm, or a thunder cloud, are taken care of by the lightning arrester. Every single occurrence that has given them trouble has been at the moment of the lightning discharge. In recent times, while they have had arresters in connection with spark-gaps, they never had any trouble with the lightning arresters themselves.

President Scott remarked that Mr. Hayward has duly emphasized the point that the men in the laboratories, the men who are building apparatus, need the cooperation of the men who are experiencing difficulties on the ground; the two must work together.

Mr. Waters suggested another method of calculating the conditions, different from that used by Mr. Mershon. He gave some results of his experience on European mountain lines of short length, the voltage being between 5000 and 10,000. Troubles arise there usually from violent lightning storms and from heavy sleet and snow storms. The universal opinion of the operating engineers there is that the grounded wire is more trouble than it is worth.

Prof. D. C. Jackson expressed the opinion that the numerical example in Mr. Mershon's paper does not represent the commercial conditions in a long transmission line. Instead of estimating the protection from the guard wire at something like 70 per cent, as Mr. Mershon does, he thinks 7 per cent, or one-seventh of 1 per cent would come nearer the truth.

Mr. Mershon, in his reply, said that his numerical example was not so far off from the actual conditions in some lines. In his paper he did not deal with electromagnetic, but only with electrostatic action. He agreed that the ordinary guard wire cannot furnish much protection against electromagnetic action.

Mr. N. A. Blanck stated that in most cases on recent Italian lines, as also on the German lines, the lightning arresters are used in the stations, never on the line itself, and the use of iron wires for protecting the line itself has been abandoned.

Dr. Perrine said he had tried to measure the loss due to the grounded guard wire, but was unsuccessful in his attempt.

In a paper with the title of

The Choice of Frequency for Very Long Lines,

Mr. Paul M. Lincoln discussed the question as to which of the two standard frequencies—60 or 25 cycles per second—is the better for a very long line, the matter being considered purely as a transmission problem. He first considered voltage regulation on a three-phase line 200 miles long, and gave a table showing the limits of transmission of low capacities. If the voltage at the receiving end is 20,000, the power which can be delivered is 500 kilowatts for 60 cycles and 1250 for 25 cycles. For a voltage of 80,000, the power is 8000 kilowatts and 20,000 kilowatts for 60 and 25 cycles respectively. If the power transmitted be large, the multiplication of lines necessary at 60 cycles unduly increases the expense of pole lines and of right-of-way for the same. This point is evidently in favor of lower frequency. The author then discussed the effect of the charging current and showed that in a 60-cycle installation it was necessary either to operate the generators on such a line at about full current output all the time, regardless of the load, or to compensate for the charging current in part or in whole by the installation of choking coils. The danger of resonance was then considered. The lower the fundamental frequency, the less the danger. While no actual trouble has ever been experienced in existing plants from this source, even with the longest lines and highest frequencies, still it constitutes an advantage for 25 over 60 cycles. In spite of these advantages of the lower frequency, the fact remains that the longest transmission line in the world (Bay Counties) and the highest voltage line (Missouri River Power Company) are both operated at 60 cycles.

In the discussion of Mr. Lincoln's paper Mr. Mailloux said that as electrical energy is used mainly for lighting the frequency must be chosen accordingly; he himself has found a frequency of 40 to be unsatisfactory for lighting; he thinks a frequency of 50 might perhaps be a satisfactory compromise.

Mr. Stott said that incandescent lighting becomes impossible at about 20 cycles, as shown by experiments which he carried out. Twenty-five cycles, with a low-efficiency lamp, taking about 4 watts per candle, at a voltage of 110, were found quite satisfactory; they made the experiment of having direct-current lighting in the draughting-room and then without notice threw it over on the alternating current, and no one knew anything about it. About 30,000 incandescent lamps in the elevated stations in New York are run now on 25 cycles and very few people notice the fluctuation. He thinks it depends a good deal upon the voltage regulation and also upon the fact that low-efficiency lamps are used.

Mr. Mershon said that in most transmission plants the condition to be met first is that of delivering power at a high frequency of 60 cycles. Then the question comes down to whether or not it is better to transmit at 25 cycles and use frequency changers for 60, or whether it is better to transmit at 60 cycles and use synchronous motors to raise the power factor of the load. If one considers the question of the investment in both cases, the 60 cycles show up much more favorably. Concerning the lowest frequency suitable for lighting, the personal element is to be taken into account; the majority of people cannot notice any effect from 30 cycles.

Mr. Rushmore said that with relation to the self-induction and capacity of the line, one must also take into account the apparatus in the circuit. The higher the voltage is which is applied, the more care must be taken that the generator e.m.f. wave should have the form of a sine wave. Messrs. Lincoln, Mershon and Perrine discussed the possibility of obtaining regulation by means of synchronous motors placed at the end of the line. Mr. Lincoln believed that the scheme of Mr. Mershon would not work. Dr. Perrine referred to a successful regulation of a line effected by Mr. Baum by means of an automatically excited synchronous motor.

Mr. Stott referred to experiments made some time ago in Columbia College and which showed that 20 or 21 was about the highest frequency at which any man could detect a flicker of incandescent lamps regularly; in fact, the majority could not detect with certainty a flicker at a frequency of 20. He also referred to a case in which arc lamps are said to have been operated quite satisfactorily at a frequency of 30. There were presented two communicated discussions of the paper of Mr. Lincoln, the one by Mr. B. A. Behrend, the other by Prof. F. G. Baum.

Mr. Behrend pointed out that in considering the question whether a frequency of 25 or 60 cycles is preferable for power transmission, one should not confine the attention to the line itself, but should take into consideration the generating plant, the transformers, and the sub-station as well. In regard to the generating plant and the transformers, a frequency of 25 is without doubt lower than desirable. In regard to the substation apparatus, a frequency of 25 is as high as desirable for rotary converters, while it is too low for lighting.

Prof. Baum also said it is not right to confine the discussion of the choice of frequency to the transmission line, because the frequency effects every part of the system, including generators, transformers and receiving apparatus. If one would take the effect on the transformers alone into account, the higher the frequency, the better. The best frequency for the generators depends on the speed at which they are driven, and on their capacity. If a system were to be laid out entirely new, including receiving apparatus, it is very probable a lower frequency than 60 would be chosen; but if the power is to be used for a mixed load of lights and motors, the frequency would be limited by the periodicity at which the flickering of lamps can be noticed, i. e., about 30 cycles. If the lines are to increase in length to 300 and up to 500 miles, it will be necessary to operate at less than 60 cycles in order to reduce the reactance volts and also on account of coming into resonance with the line.

Power Station Economics

Messrs. W. E. Goldsborough and P. E. Fansler, in a lengthy paper on this subject, give the results of a careful test of the economy of the main power station of the Union Traction Company of Indiana. It contains eight 400-h.p. water-tube boilers, three engines each with a maximum capacity of 2000 horse-power, direct-connected to a 1000-kw., three-phase generator. The methods of the test are described in detail. The results giving the thermal efficiency of the plant are as follows: The efficiency of the furnaces and boiler is 79.6 per cent, i. e., 79.6 per cent of the whole heat in the coal as fired is delivered by the boilers to the engines in the steam. The average thermal efficiency of conversion between the boilers and engine cylinders is 9.11 per cent, i. e., 9.11 per cent of all the heat delivered in the form of steam by the boilers is converted into work in the cylinders of the main engines. This value of 9.11 per cent credits against the engines the steam used in the auxiliaries. If the assumption is followed out that 15 per cent of the steam delivered by the boilers is consumed by the auxiliaries, the thermal efficiency of the engines works out to be 10.7 per cent. The average total thermal efficiency of the plant is 7.25 per cent from the coal pile up to the engine cylinders. and the total average thermal efficiency of the plant from the coal pile to the switchboard, i. e., the ratio of the energy delivered by the generators to the total heat in the coal, is 6.39 per cent.

Although it is frequently stated that the thermal efficiency of the steam engine at a maximum is about 25 per cent, it is impossible that any engine of this class working under these conditions will convert more than 12 per cent of the heat of the coal into work. The thermal efficiency of 6.39 per cent up to and including the switchboard shows high economy as compared with other stations of a similar character. The total thermal efficiency of the Harrison Street station of the Chicago Edison Company has been estimated to be 4.5 per cent, while that of the generating station of the Blue Island, Chicago Storage Battery Road was found to be 5.5 per cent. Indiana block coal is used, which is delivered at a cost of $1.35 a ton. On this basis the cost of developing one kw.-hour is 0.28 cent. This cost may be taken as the final estimate of the efficiency of any station; figures of this cost in various stations vary between 0.246 and 1.016 cent.

After the reading of the above paper, Prof. Goldsborough said that the station described delivers to the line 6.23 per cent of the total energy of the coal, but that only 3.65 per cent of the total energy gets to the cars. The efficiency of transmissions between the station and the cars is, therefore, only 50 per cent. Mr. M. H. Gerry said that if everything were included between the electrical output of the station and the electrical input at the cars, the total efficiency of the plant at the car axle would certainly be reduced 25 to 30 per cent more, bringing the total ideal efficiency of the installation down to or around 2 per cent. Prof. Goldsborough considered this to be a fair assumption, but he pointed out that power is developed so cheaply that this becomes a small factor, one passenger per car pretty nearly paying the cost of the power used by a car from Indianapolis to Muncie, the fare, moreover, being only one cent a mile. A good deal of money is being made on this basis, the property being a profitable one.

Mr. Gerry said that the plant was not an example of a high efficiency or even of an average efficiency plant. Prof. Goldsborough replied that the plant has a very high financial efficiency, which he considered to be a better than a high-power efficiency. To reduce the transmission losses would increase the capital charge, which increase might more than balance the cost of coal. Mr. Gerry said that he did not see why a high-efficiency station should be installed to make power cheap and then a low-efficiency distributing system put up which will waste that power afterwards. If one can produce power cheaply and wants to keep down the first cost of a station, he should not put in a modern high-class system all the way through. In reply, Prof. Goldsborough said that if a low-class generating station, low-class transformers, low-class rotaries and batteries were put in, the cars would not get the required per cent of power of the total energy generated. The present station has the highest class of generating machinery and should it become necessary to increase its earning capacity, all that would have to be done would be to increase the copper in the lines. There is no excuse for putting in bad machinery, but when it comes to the size of copper conductors, that is another thing. At present the voltage is 18,000, but in extending its system to Logansport the company will use 32,000 volts. Perhaps some day, instead of operating with a direct current of 5,000 volts, it will operate with an alternating current of 10,000 volts. Mr. Gerry, in reply, said that the highest efficiency machinery designed did not always give the best operating result, and to him it is a question whether in this case refinements were not made in the station and sacrifices in the transmission system.

Mr. H. G. Stott said that the ultimate object in any power plant is to deliver a kilowatt-hour to the receiving apparatus at a minimum cost, and that there is no other object in a power plant. If the coal is expensive, an extremely efficient plant must be put in; but if coal is very cheap one can afford to sacrifice a good deal and reduce the cost charges of the plant. In the end, however, one must consider the whole problem; that is, the cost of the kilowatt-hour delivered at the receiving apparatus. He considered that in the paper just read the fuel cost is only given, whereas the total cost of the delivery of power is the real test. In the New York Manhattan plant the cost of coal is 70 per cent of the total operating expenses up to the track of the elevated road, and consequently an extremely efficient distributing system and power plant is required. He thought that any comparison of efficiencies was unfair when calculated merely on the ratio of indicated horse-power to kilowatt-hour output. Mr. Mailloux agreed with Mr. Stott and said that the real question is what is the kilowatt-hour going to cost delivered. He said that recently he was approached by a representative of a concern making gas engines, in connection with a plant of 20,000 kilowatts, which he is designing for railway work, who made the statement that he could enable him to save $100,000 a year in fuel. Mr. Mailloux found that he could, with the engines proposed, make a very material saving in coal, but that the additional cost of buildings would be greatly increased; for instead of being able to use three large turbine units of 4000, 5000 or 6000 kilowatts each, he would have to use ten gas engines. The initial investment would be one-half million dollars greater, and considering the fixed charges and the cost of producing power, the proposition entailed a loss of $100,000 a year instead of that much gained. This example illustrates the necessity of taking all circumstances into consideration in making a comparison of methods of producing and delivering current.

Mr. Gano S. Dunn referred to the vague manner in which the term "cost" is used, and thought that it would be well never to use that word without defining what it was intended to include. It would be desirable when costs are considered before the Institute or for statistical purposes, that they should include fixed charges, taxes, depreciation, sinking fund charges, interest on bonds, and every other factor, as well as the charge on any extra cost in the way of buildings or otherwise that a proposition entails. Our statistics on the subject of cost of power are of very little use, because of the lack of definitiveness in specifying what we mean and what we include when we say "cost." Mr. Paul Lincoln said that the question which Mr. Gerry raised seemed to be simply a question of Kelvin's law. Power can be developed for a certain sum at a station, and it is merely a question of how much of that shall be lost in the line. If power is cheap, more power can be lost in the line than if power is dear. It is for an engineer to determine whether he shall put money or energy into his line. Mr. Mailloux said that he could mention many cases where cost of fuel has a very great bearing upon the selection of machinery and the design of the installation. Mr. John F. Kelly said that the heedless application of Kelvin's law would be apt to lead to considerable bad engineering. The law has an important proviso, namely, "provided that other things be equal." If the energy generated is used for lighting, it must be delivered at a practical constant voltage, which limits the application of the law in that particular case, and the same may be true in other cases. Referring to the system described by Prof. Goldsborough, he was inclined to think that the discrepancy between the two parts was due to the fact that the cheaper station was laid out by an engineer, and the other part put up by a lineman. He agreed with Mr. Gerry that very often the low-efficiency machinery is much more stable, may run better and last longer than the higher grade machinery. Mr. Gerry agreed with Mr. Dunn that power data as a rule are absolutely worthless because the various factors that enter in cost are either not included or are based on assumptions so much at variance that one plant cannot be compared with another. Another point which affects the cost of power is the form of the load curve. He suggested that for determining cost, certain rules be formulated, certain interest charges determined upon, certain relations established between average and maximum power; in other words, all station factors should be taken into consideration in a definite way, and we might then arrive at a form of stating the cost of power so as to make comparisons possible within a few per cent of error. President Scott said that Prof. Goldsborough had rested upon the cost of fuel per kilowatt-hour output, which is an entirely accidental thing; for the cost of coal varies greatly, and the discovery of a coal mine in the vicinity might reduce its cost to half. It has been suggested that the total cost should include cost of handling and attendance, but that would depend upon the current rate of wages in any part of the country. He thought that in consideration of such problems, two things should be considered separately—first, the purely engineering problem, and then the application of the engineering to the commercial problem. In concluding the discussion, Prof. Goldsborough said that the reason no more figures were given in the paper was because he could not obtain the consent of the owners of the plant to print all the data which he had obtained. Replying to Mr. Kelly, he said that if one were to inspect the line in question, which carries 16,000 volts on the top of the pole, 500 volts half way down and a telephone line a little bit lower, all three of the lines working perfectly with no disturbance in the telephone system—he would not conclude that the line gave evidence of bad engineering.

Besides the foregoing papers, interesting papers were presented as follows: Calvin W. Rice, on "Institute Branch Meetings, their Organization, Development and Influence"; W. S. Franklin, on "The Energy Transformations in the Synchronous Converter"; W. L. Waters, on "Commercial Alternator Design"; A. H. Armstrong, on "High-Speed Electric Railway Problems"; Frank L. Sessions, on "Storage Battery Industrial Locomotives"; F. W. Carter, on "Predetermination in Railway Work"; W. E. Goldsborough and P. E. Fansler, on "Car Run Tests"; Samuel Sheldon and J. D. Keiley, on "Some Recommendations Concerning Electrical and Mechanical Specifications for Trolley Line Insulators"; Clarence Renshaw, on "Notes on the Operation of Railway Motors in Service"; P. H. Thomas, "On the Testing of Electrical Apparatus for Dielectric Strength"; J. Walter Esterline and Clarence E. Reid, on "The Factors which Affect the Energy Losses in Armature Cores"; R. L. Montague, on "The Electrical Equipment of a Gold Dredge"; H. S. Carhart, on "The Legalized Standard of Electromotive Force"; A. E. Kennelly, on "The Magnetic Units"; Harris J. Ryan, on "The Cathode Ray Alternating-Current Wave Indicator"; and A. W. K. Pierce, on "Some Notes on Certain Underground Hoisting Problems on the Witwatersrand." We regret that space limitations preclude even a brief abstract of these. On Monday evening, June 29, P. H. Thomas gave an exhibition of the Hewitt converter and the mercury vapor lamp. On the last day of the convention, a joint meeting was held with the Society for the Promotion of Engineering Education, at which the following papers were presented: "The Teaching of Physics to Electrical Engineering Students," by W. S. Franklin; "The Problems that are Facing the Electrical Engineer of To-Day and the Qualities of Mind and Character which are Needed to Meet Them," by J. G. White; "The Proper Qualifications of Electrical Engineering School Graduates, from the Telephone Engineer's Standpoint," by Bancroft Gherardi, Jr.; "The Proper Qualifications of Electrical Engineering School Graduates, from the Manufacturer's Standpoint," by L. A. Osborne; "The Education of the Artist in the Forces of Nature," by E. H. Mullin, and "Engineering English," by T. J. Johnston.

An Oil Engine Central Station.

BY HOWARD S. KNOWLTON.

A radical departure from existing central station plants is afforded by the new electric light plant at Jewett City, Conn., a town of about 3000 inhabitants, located on the Worcester division of the New York, New Haven & Hartford Railroad, some ten miles from Norwich. The new plant, which was started about the middle of July, has the distinction of being the first central station in this country to adopt the Diesel oil-burning engine as its source of motive power, and represents an interesting example of elimination—no boilers, stacks, coal bins, stokers, economizers, or heaters being necessary. Compactness is the key-note of the whole design. Until the new plant was started, Jewett City was lighted electrically by a 60-kw. Westinghouse 2200-volt 60-cycle single-phase alternator driven by water-power at the Aspenock Bleachery. The claims made for the Diesel engine, convinced the town authorities that a new station could be operated with profit, and the result represents one of the most advanced types of small lighting plants to be found in the East.

The power station is located on the west bank of the Pachaug River. It is a neat brick building one story high, with a monitor capped roof. The length of the structure is only 37 ft. 8 ins., and its width is 30 ft. 8 ins., while the height from the top of the foundations to the top of the monitor figures up about 26 ft. A small brick chimney about 8 ft. high carries away the products of combustion discharged from the engine cylinders; before entering the chimney, the exhaust gases pass through a muffler. The interior brick walls are painted white, and the station is well provided with windows on all sides.

At present there is but a single room in the plant. The height of the room is 14 ft. from the floor level to the bottom of the horizontal beams of the roof truss. Space has been provided for a small office in the northwest corner of this room. A double door 5 ft. wide is built in the west wall to permit the easy ingress or egress of machinery. Probably one corner of the room will be fitted up as a repair shop later on.

The oil supply for the engine is drawn from two storage tanks set underground near the station. Their combined capacity is 6500 gallons. The oil, which is crude, is brought to the plant in tank wagons holding 640 gallons, and costs 4.6 cents per gallon delivered. It is pumped from the main tanks to a vertical tank holding 40 gallons, and from this tank it is supplied to the engines.

The generating plant consists of two 60-kw. Westinghouse single-phase 2200-volt 60-cycle alternators, belt driven by two 75 brake horse-power triple-cylinder Diesel oil engines, of the vertical marine type. The engine cylinders are all 15 ins. stroke and 10 ins. diameter. The indicated horse-power of each engine is about 100.

The engines constitute the most interesting feature of the plant and were built for the American Diesel Engine Company, of New York, by the International Power Company, of Providence, R. I. They operate on the well-known Otto cycle of admission, compression, combustion, expansion and exhaust, but differ radically from ordinary gas and oil engines in the character of the combustion. This is not of explosive character, but is steady combustion at high compression temperatures. During the compression stroke the cylinder contains air only, and the temperature due to compression ignites the combustible charge without the need of electric spark or ignition tube apparatus. The clearance is about 7 per cent of the cylinder volume, and the combustion of the vaporized oil does not increase the pressure caused by the compression. The cylinders are symmetrically mounted on the engine housing and drive a single shaft through cranks having 120 degrees displacement.

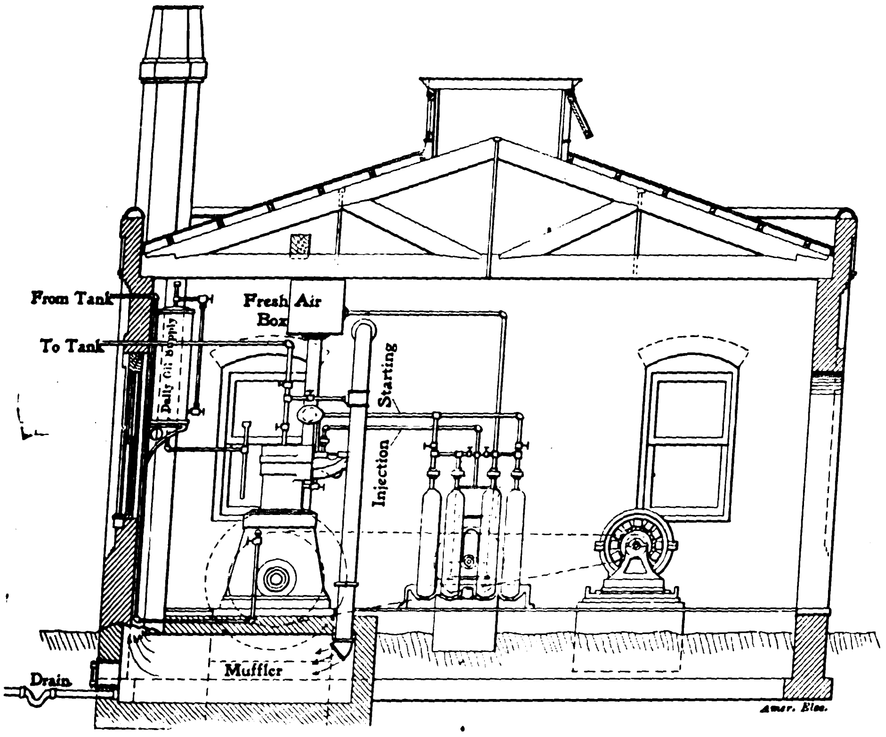


FIG. 1.—TRANSVERSE SECTION OF POWER HOUSE.

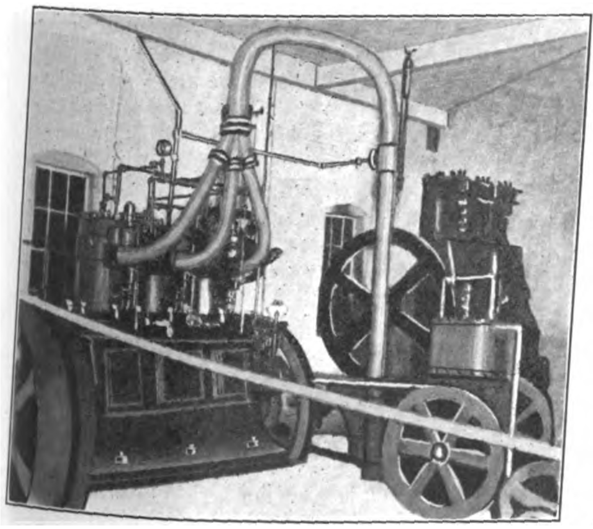


FIG. 2.—CORNER OF ENGINE ROOM.

The valve operating cams are on the usual secondary shaft driven by the main shaft through an intermediate gear. The admission and exhaust valves are driven by two of these cams. The movement of the admission valve particularly is very slight. The oil is driven into the cylinders by compressed air through a series of perforated brass washers, and enters the cylinders in the form of a fine spray; an auxiliary air compressor, driven by belt from the engine, supplies the air for this purpose. The air which supports the combustion is drawn into the cylinder through an automatic mushroom valve, and is compressed on the up stroke to between 450 and 525 lbs. pressure per square inch, corresponding to a temperature of about 1000 degrees Fahr. The fuel valve is open for about one-tenth of the working stroke, and the fuel is let in and consumed during the whole or a part of this period as determined by the action of the governor. At the termination of the fuel supply, the resulting gases of combustion work expansively during the remainder of the stroke. The combustion is singularly complete on account of the large quantity of oxygen in the cylinder at the beginning of the working stroke. Any grade of crude or fuel oil may be employed in the engine.

The fuel oil is delivered to the fuel-admission valve by a pump driven from the cam shaft. One pump cylinder is provided for each of the main cylinders, and back of each is a by-pass valve, which, when open, allows the oil to flow again to the suction side of the pump instead of to the fuel valves. The length of time that these by-pass valves are open is controlled by the governor, which is of the centrifugal "Begtrup" type. The by-pass valves are opened by three arms that are pivoted at one end on a shaft that the governor raises or lowers. These arms are operated by connecting rods driven by eccentrics on the pump-driving shaft. By a link connection, the governor collar thus increases or lessens the distance between the top of the by-pass valve rods and the arms which open them. Upon the relative distance between the top of each valve rod and its corresponding arm depends the length of time the valves are open, and the consequent duration of oil supply for combustion purposes.

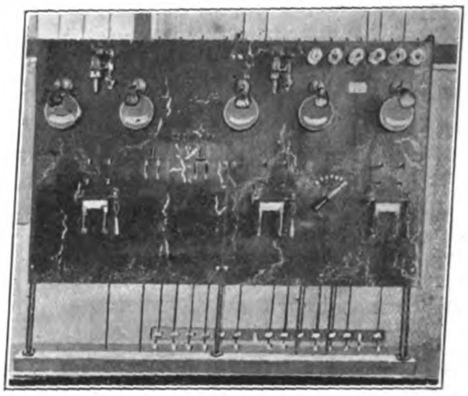


FIG. 3.—SWITCHBOARD.

After the fuel valve closes, the gases work expansively, and the atmospheric and terminal pressures differ but little. The effect of the compressed air used to inject the fuel is inappreciable. The admission valve is open a constant length of time, but the fuel supply is controlled by the governor as just described, so that only at full loads is it injected into the cylinder during the entire period that the valve is open. It has been stated that the thermal efficiency of the Diesel engine runs as high as 38 per cent.

In general outward appearance the engine resembles the ordinary marine type of steam engine. The connecting-rod is carried directly to a pin inside the piston, as usual in single-acting engines. The reciprocating parts are all enclosed within the engine housing, which is fitted with detachable plates for easy access. Lubrication is automatic, a large oil well in the lower part of the housing service as a bath into which the connecting-rod crank end plunges at every revolution. Double fly-wheels are provided for each engine in addition to the driving wheel.

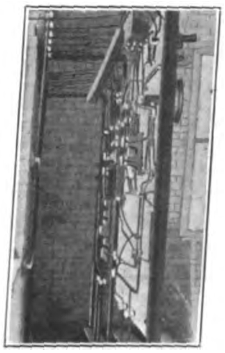


FIG. 4.—REAR OF SWITCHBOARD.

The engines are started by compressed air from auxiliary reservoirs, which are filled by the engine-driven compressor already mentioned. The attendant opens a starting valve which admits compressed air to drive the piston for two or three revolutions, after which the compression in the cylinder is sufficient to ignite the charge; the starting cam is thrown out of action automatically as soon as the attendant throws in the admission and exhaust valve mechanism. Enough air is always stored in these reservoirs to enable the plant to start with ease.

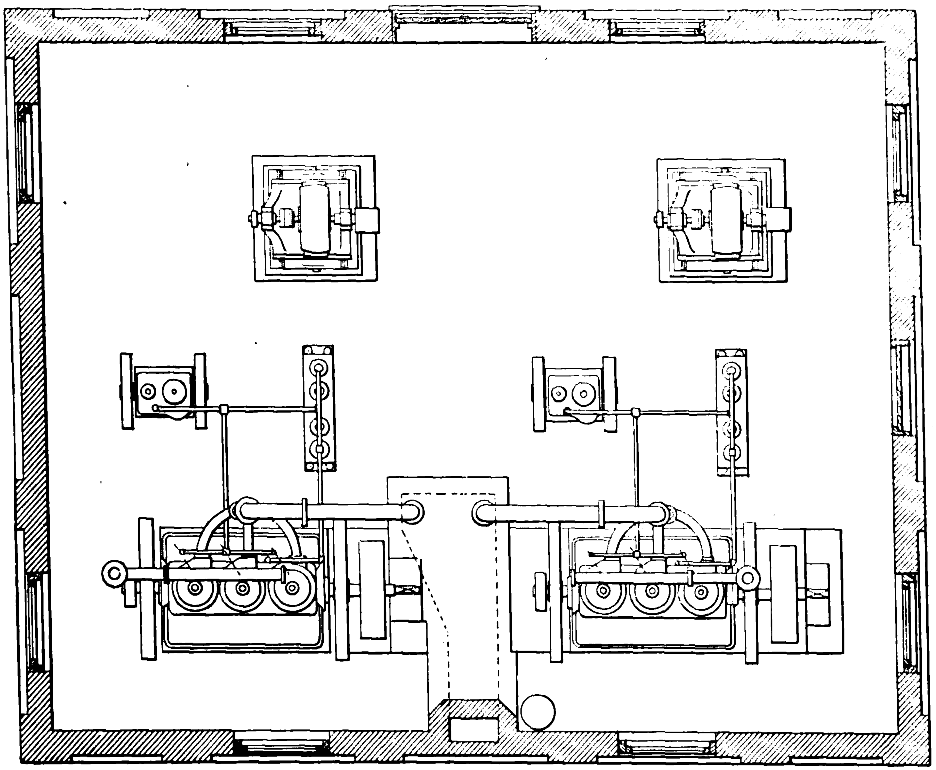


FIG. 5.—PLAN VIEW OF STATION.

In the drawings of the plant reproduced herewith, the auxiliary reservoirs are not shown located exactly as finally installed; but no essential feature has been changed. On the east side of the building, just outside of the engine-room wall, is located a wooden water tank with a capacity of 7,000 gallons. The water from this tank is circulated through the jackets of the engines and is used over and over again. Each engine drives a small pump beneath the floor which replenishes this tank when necessary.

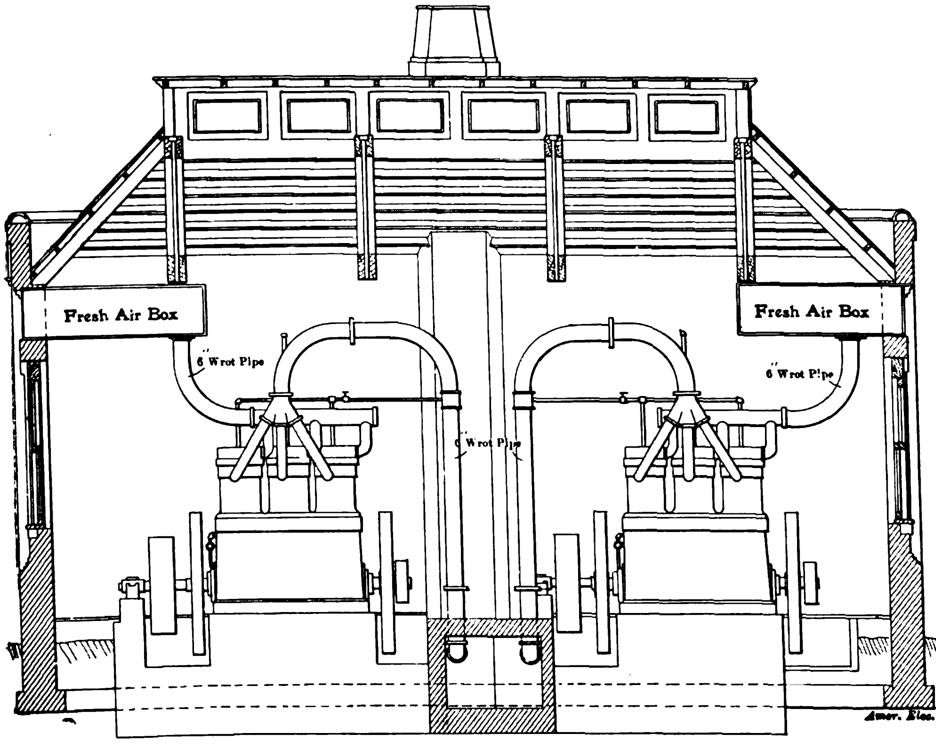


FIG. 6.—ELEVATION AND ARRANGEMENT OF ENGINES.

Each of the two alternators is mounted on timbers, and is compound wound, driving its exciter by belt. The exciters are each 1.5-kw. 125-volt machines, and run at 1,300 r.p.m.; these are also mounted on short timbers for insulating purposes. The wiring from machines to the switchboard is carried below the floor level, and all 2200-volt circuits are run in lead-covered cable.

The switchboard is located on the south side of the generator room, and is composed of two panels of special marbleized slate supported by a steel tubing frame. Rubber mats are to be placed in front of both machines and switchboard. The board is 8 ft. long and 5 ft. high. Each machine is protected by an Elden circuit-breaker which is modified so as to short-circuit the compounding winding at the rectifier after the exciter circuit has been opened automatically. Each panel contains a machine voltmeter and ammeter in addition to the circuit-breaker, and a double-throw, double-pole interlocking switch for connecting the commercial circuits to either alternator. In addition, one panel carries two double-pole single-throw exciter main switches, and a double-pole, double-throw horizontal station lighting switch which throws the 12 to 16-c.p. incandescents which illuminate the plant, upon either exciter.

One of the panels also contains a double-pole double-throw quick-break switch for connecting the series street lighting incandescent circuit with either alternator. To provide against excessive voltage at the lamps, in case any one of the series incandescents burns out and short-circuits through the base, six lamps have been installed on one of the panels in connection with a radial switch, which throws them in circuit one by one as may become necessary to replace burned-out lights. The street lighting circuit is also provided with an indicating ammeter. Rheostats for the alternator fields are to occupy the lower central portion of one panel of the switchboard.

The station wiring is run in neat parallel lines from the switchboard along the wall to the apertures where the circuits leave the building. At present there are two single-phase commercial circuits supplying house to house transformers, and one street series circuit made up of 30-c.p. 5.5-ampere incandescent lamps. The total connected load is equivalent to about 2000 16-c.p. lamps at present. There are no direct-current circuits in the town.

The economy of operation shown by the Diesel engines is of interest. The machines in the new plant are guaranteed to operate on 0.47 lb. of oil per brake horse-power-hour at full load, and on 0.5 lb. oil per brake horse-power-hour from friction load to full load. With oil at 4.6 cents per gallon, this means about 1 cent per kilowatt-hour, including wages and supplies, the attendance required being very small. The high efficiency of the engines, added to the small relative cost of attendance on account of the simplicity of the apparatus, gives the Jewett City plant every prospect of financial success if it is properly operated. The estimated cost of operating an equivalent steam plant was prohibitive. The present plant is owned by the town, and it is expected that the gross receipts, which last year were about $6500, will be greatly increased as a result of the reduced cost of the service. The results of operation at Jewett City will undoubtedly be watched with special interest by those who are concerned with the development of lighting and power enterprises in small towns. The plant was installed by H. B. Rust & Co., of Providence, R. I.

ALTERNATING CURRENT MOTORS FOR VARIABLE SPEED.

BY W. I. SLICHTER.

The impression is very general that a variable speed cannot be obtained with an alternating-current motor, and that if an alternating-current plant is to be installed, the idea of obtaining a variable speed drive of any of the tools must be abandoned. This is not so, and the object of this paper is to show the possibilities of this type of motor, and to point out its limitations. But it must be understood in the first place that it is not claimed for the alternating-current motor that it can compete with the direct-current type where continual variations of speed, throughout a wide range, are required, as the latter motor is usually superior in efficiency under these conditions.

The speeding of an alternating-current motor may be controlled in a number of ways: (*a*) By varying the potential applied to the primary of a motor having a suitable resistance in the secondary; (*b*) By varying the resistance in the secondary circuit; (*c*) By changing the connections of the primary in a manner to change the number of poles; (*d*) By varying the frequency of the applied voltage.

For the benefit of those not familiar with the polyphase induction motor, a general view of its characteristics may be desirable. These characteristics are very similar to those of the direct-current shunt motor—that is, at a constant impressed voltage and frequency the speed tends to be constant, and a considerable change in load will not cause an appreciable change in speed. As the load increases, the speed drops gradually to a critical point, usually about 15 to 20 per cent below the normal value, and then the motor breaks down completely if the load is any further increased. The same action occurs if the load is kept constant and the voltage decreased. But if the frequency of alternation of the impressed voltage is decreased, the speed will decrease in exactly the same proportion. That is, for a given frequency and a given number of poles in the motor, the speed is practically fixed and independent of all other effects. The one exception to this last rule is the effect of the resistance (or losses) in the secondary (usually the rotating) member.

The drop in speed from the synchronous value is directly proportional to these losses. Thus, by increasing the resistance of this circuit, any desired speed may be obtained at the expense of these losses. With the increased resistance, the speed at which the motor breaks down may be reduced to a very low value, even to zero speed. Thus, by reducing the voltage applied to the motor for a given torque, the effect is produced of overloading it, and the speed drops. These characteristics are equally true for the two-phase or three-phase motor, of course, as the two motors are practically identical in their construction.

In this connection it should be remembered that a variation of an alternating voltage may be obtained by means of a reactance or compensator with a very small loss of energy, whereas with a continuous voltage the loss of energy is usually proportional to the variation in voltage.

Taking up the methods in the order enumerated, we will analyze their characteristics.

Potential Control.—In this a suitable reactance or "compensator" reduces the line voltage to the fractional value desired. In this reduction the energy lost is only about 5 per cent of the amount transformed.

The induction motor should have a very large resistance in the secondary, which is preferably of the squirrel cage type. This resistance gives the motor a speed characteristic such that its full load speed is some 10 per cent less than that of a normal motor, and as the load is increased, the speed will fall to about 30 per cent of this value without the motor "breaking down" or falling out of step, which in the normal motor usually takes place at about 80 per cent of the full load speed. Such a motor would have the following characteristics, with constant full load (50 horse-power) torque at various speeds, assuming its synchronous speed as 1.00, and the voltage applied as 100 (this is based on a 50 horse-power, 40 cycle motor, at 800 revolutions per minute, as an instance):

	Speed.	Volts.	Efficiency.	Motor loss.	Compensator. loss.
Full load speed	.89	100	81%	8.8 kw.	0.0 kw.
Three-quarter load speed ..	.67	66	59%	18.5 kw.	1.0 kw.
One-half load speed	.45	57	37%	32.0 kw.	2.0 kw.
One-quarter load speed ..	.22	56	17%	45.7 kw.	3.5 kw.
Normal motor (full speed).	.98	100	88%	5.0 kw.	0.0 kw.

From this we see that the principal and worst characteristic of this plan is the increased loss in the motor (thus increased heating) with the decreased speed. This means that the motor must be larger than normal.

Rheostat Control.—In this scheme the secondary or rotor must have a definite winding (as contrasted with the squirrel cage, which is cheaper) with slip rings and brushes to lead out the current. The friction and resistance losses due to these brushes decrease the efficiency of the motor somewhat; the secondary is usually wound for a higher voltage and less current than in the standard or normal motor, to minimize these losses. This scheme would show the following characteristics for the same motor as before at 50 horse-power torque constant:

	Speed.	Volts.	Efficiency.	Motor loss.	Rheostat. loss.
Full load speed.	.96	100	86%	5 kw.	0.0 kw.
Three-quarter load speed ...	.72	100	65%	5 kw.	9.0 kw.
One-half load speed	.48	100	43%	5 kw.	18.5 kw.
One-quarter load speed	.24	100	22%	5 kw.	28.0 kw.
Normal motor (full speed)...	.98	100	88%	5 kw.	0.0 kw.

As will be seen, this method gives a higher efficiency throughout, but particularly excels the previous method in having so much smaller losses in the motor itself, thus permitting of a smaller machine and less danger of damage. The losses are concentrated in a rheostat.

Changeable Poles.—By using a pitch of winding which is commensurable with two numbers of poles, we may build a motor which will operate with either 4 or 8, 6 or 12, etc., poles, by a slight change of the connections. Or by a more intricate arrangement of windings a change from 4 to 6, 6 to 8, etc., may be made. In this arrangement it is necessary to use a squirrel-cage armature, since it is suitable for any number of poles, and the pitch of the primary coils has to be made some compromise value between the normal pitch of the two combinations, so it is usually not the best or most effective pitch for either number of poles. Therefore the constants of this motor should not be expected to be as good as those of the standard motor.

Of course such a motor operates advantageously only at two speeds corresponding to the synchronous speeds of the two arrangements. Thus, a 12 and 6-pole motor at 40 cycles would operate at either 400 or 800 revolutions respectively. If a wider range is desired, the potential control scheme first mentioned may be combined with it.

For a motor operating at full and half speeds, say with 6 and 12 poles for 800 and 400 revolutions, we would have:

	Volts.	Efficiency.	Losses.
Full speed, 50 horse-power..	100	86%	5.8 kw.
Half speed, 25 horse-power ..	100	74%	6.6 kw.

Thus, for full load torque at half speed the efficiency is almost double that obtained with the other methods, but what losses there are are in the motor itself, as in the first case. The losses are about the same in the two cases.

Variable Frequency. — Every induction motor tends to run at synchronous speed—that is, at a speed equal to (60 × frequency) ÷ ½ number of poles, so that if the frequency is changed the motor will run at a different speed. Some installations have been made where two or three alternating current generators are used to obtain different frequencies, and these circuits are carried around the shops by various sets of lines (usually three in each set) and the motor connected to the lines giving the frequency and speed desired. For normal losses in the iron the voltage must vary with the frequency. Thus for full and half speed we have:

	Volts.	Efficiency.	Losses.
Full speed, 50 horse-power ..	100	88%	5 kw.
Half speed, 25 horse-power ..	50	87%	2.8 kw.

Generators have been built having two stationary armatures in the same frame and two revolving fields, with a different number of poles on the same shaft to give the multiple frequency desired. An application of this principle, which is very pretty theoretically, is that of a very small variable speed induction motor (whose losses are negligible) which drives a commutator feeding the primary of the large motor; by a suitable control of the little motor any desired frequency may be supplied to the large machine from zero to full value, and it may be started and run at any desired speed. A variation of this is to attach the commutator to the shaft of the working machine and the brushes to the shaft of the controlling motor, so that when the work machine is standing still the brushes revolve at almost full speed on the commutator, and a very low frequency is obtained in the commutated circuit. As the work machine speeds up, the difference in the speeds of the commutator and the brushes decreases, and hence the frequency increases, until that time when the commutator and brushes are revolving together at the same speed when there is no commutation and the load machine receives full frequency.

From these descriptions it will be seen that the changeable pole and variable frequency methods are the most efficient, but do not permit of a variation through a wide range of speed. The rheostatic control is the simplest and easiest of control, giving a range from standstill to full speed, but is not as efficient as the first two, although more efficient than potential control. The last mentioned has the disadvantages of low efficiency and considerably increased heating in the motor itself, and is also unstable at low speeds, say below one-third speed. That is, a small variation in torque or a smaller variation in voltage will cause a considerable variation in speed.

Potential control is used where moderate variations in speed are wanted, not reaching to less than half speed for instance, and where the load is intermittent, not giving the motor a chance to get too hot. Its great disadvantage is the amount of current it takes at starting, which causes considerable disturbance in the supply circuit, flickering of lights, etc., due to the drop in voltage. The motor used is a cheaper one to build (for a given output) than the others, but if anything like continuous running is desired, the motor must be larger, so that much of this advantage is lost. One advantage of this motor is that it may be totally enclosed for use in powder mills, oil refineries or where much dust or corrosive vapor is encountered, as it may be controlled from a distance without increasing the number of wires.

The rheostatic method is particularly adapted to cases where frequent starting and low speeds are required, as it causes no unusual drain on the supply system when starting. Thus, it is used for hoists, elevators, etc.

The changeable pole system has the same disadvantages in starting as the potential control. For long-continued running at only two different speeds it is excellent, and has constants comparable with those of a direct-current motor.

To vary the frequency of the current supplied to the motor requires an increased investment in generating station or auxiliary apparatus and line copper, and the greater the number of speeds, the greater this complication; but in operation and economy the method is equal to any.

One point which is important to bring out is that with the changeable pole and changeable frequency systems the motor will not vary appreciably from the set speed for changes of load, while with either potential or rheostatic control, a change of load will cause an appreciable variation from the desired speed, requiring a readjustment of the potential or resistance to bring the speed to the desired value again.

(The foregoing is a paper read before the Saratoga meeting of the American Society of Mechanical Engineers.)

Abstracts from Foreign Contemporaries

Conical Pole-Pieces.—According to the *Elektrotechnische Rundschau,* D. Bergmann, of Stockholm, has introduced conical pole-pieces for dynamos and motors in place of the ordinary cylindrical ones now in general use. The object is to minimize the magnetic leakage and therefore the opposing action of the counter ampere-turns of the armature by reducing the pole-piece surface, the mean distance from pole to pole, and the density of the magnetic flux at the part adjoining the base of the cone. By this means, it is claimed that in the case of direct-current machines it is possible to increase the ampere-turns of the armature and thus the output of the machine without increasing the sparking or the distortion of the field.

Improvement in the Nernst Lamp.—In order to avoid the partial absorption and screening of the light emitted by the filament of the Nernst lamp, the *Allgemeine Elektricitäts Gesellschaft* proposes to replace the helical heating coil, now in general use, by a flat heating coil. According to the London *Electrician,* the necessary investigations are not quite concluded, so that this new form of burner may not make its appearance for some months. The heating coil, as shown in Fig. 1, is arranged above the filament and rests against a bright porcelain backing which is slightly curved and serves as a reflector. The filament itself is similar to that of the old patterns. In order to increase its stability, however, it is supported in the middle by a short connection to the porcelain body. The filament, the heating coil and the porcelain backing are placed as near together as possible, the main object being to keep the temperature of the porcelain reflector at such a value that evaporated platinum from the leads cannot deposit upon and blacken the reflector.

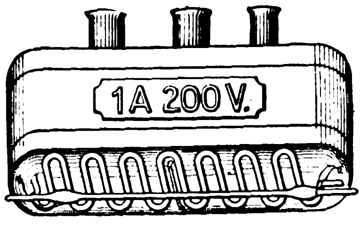


FIG. 1.—NERNST LAMP IMPROVEMENT.

Stuffing-Boxes Without Packing.—At a recent meeting of the Mining Institute of Scotland Mr. Andrew Watson read a paper on "Stuffing-boxes without Packing." The author described how Mr. Henry Aitken had forty years ago devised a simple, ingenious, and effective arrangement for economizing steam and packing in connection with what are known as the stuffing-boxes of engines and force-pump piston rods. The 3-coupled winding engines at Cadzow Colliery, Hamilton, with cylinders 24 in. diameter and 5 ft. stroke, had been altered to suit the arrangement referred to by fitting a cast-iron horn upon the stuffing-boxes. The inside of the horn was bored out to a diameter, so as to allow the piston rod to move in and out with freedom. The horn had grooves cut out 1 in. apart along its whole length, each being ¼ in. in width and depth. At the end of the horn, which entered the stuffing-box of the cylinder, a ring of white metal, the internal diameter of which was the same as that of the piston rod, with a thickness of ⅜ in., and a breadth of 1⅛ in., fitted into the check turned out of the end of the horn and the brass bush. The first engine fitted in this way had the horn cast upon the cylinder cover and bored out as before described. As a precaution a stuffing-box was placed upon the end of the horn of the first engine so made, but no packing was used. This engine was in use for a period of 15 years, after which it was sold, and all trace of it had been lost. At Cadzow Colliery, Hamilton, working under full load, it had been found that since the horns had been adopted in the winding engines full steam was admitted for 8½ revolutions, whereas when ordinary packing was in use steam was admitted for 9½ revolutions. It should, however, be noted that before the horns were fitted the piston rods were not in good condition. Experiments made with one of the pistons of these winding engines showed that when disconnected from the crosshead, and in a position ready for work, the piston and rod, weighing fully 9 cwt., could be easily pulled by one man along the cylinder. A Salter spring balance was fixed to the outer end of the piston rod and registered 100 lbs., the power necessary to start and move the piston rod. These horns had been in use at Cadzow Colliery for six years, and the repair and upkeep of the same were practically nil. It seemed strange, the author continued, that so effective a contrivance had been in use for over 40 years without being generally adopted, because in addition to the economizing of steam, the saving in gear packing is considerable.

New Oil Engine.—The London *Engineer* describes the oil engine shown by Fig. 3, which was designed by V. R. Nicholson, whose object was to reduce the number of working parts and to simplify the action of the engine so that it could be safely trusted in the hands of non-experts.

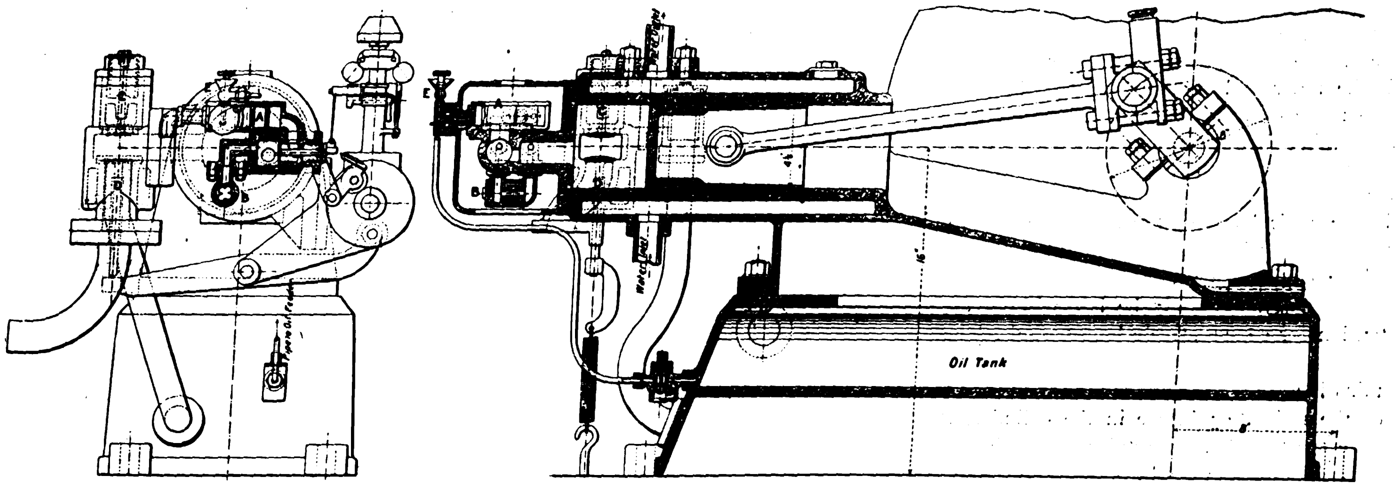


FIG. 2.—FRONT AND SIDE SECTIONAL ELEVATIONS OF OIL ENGINE.—FIG. 3.

The engine works on the Otto cycle: It uses ordinary petroleum. There is no oil pump and no external ignition apparatus—neither lamp nor electric connections. Except that the design of the engine as a whole has been carefully thought out, there is nothing particular about it. A crank is driven by a piston in the usual way, and the oil tank is in the engine base. The governor, moreover, presents no new features. The centrifugal type is used in preference to the pendulum or inertia governor, but the control is still by hit-and-miss. The entire charge is cut out, so that at all loads a uniform mixture is maintained. The details of construction of the governor have been carefully thought out, and attention has been paid to the reduction or equalization of friction by proper lubrication, so that it works with certainty and precision. It is, however, in the vaporizer and igniter that the chief interest is to be found. Several detail sections of the vaporizer will be found in Fig. 4. An oil pump is dispensed with. On the suction stroke the working piston draws a charge of oil into the vaporizer. This is, as shown, a flat cast-iron box, *A*, with baffles which cause the oil and its vapor to travel backward and forward through passages, which are initially heated by a blow lamp. The igniter, *B*, is immediately below the vaporizer. It consists of a tube with thin internal ribs, which, having once been raised to a temperature sufficiently high to cause ignition, maintains that temperature without the application of an external flame. This igniter is connected by passages with the vaporizer in such a way that a portion of the rich charge passes through it on its way to the combustion chamber. On the return stroke the compression causes the charge remaining in the igniter to explode and fire the rest of the charge. Referring to the detail drawings, *a* represents the cylinder, *b* the combustion chamber, and *c* the vaporizer attached to the outside of the combustion chamber, *b*. The internal partial partitions, marked c_1, c_1, cause the oil, which enters through the inlet, *d*, to be drawn by the air entering through the air inlet, d^1, in a zig-zag path, so as to be presented to an extensive heating area before passing to the combustion chamber. *e* is an auxiliary chamber, which is in connection with the vaporizer by the passage, *f;* this passage is controlled by the valve, *g*, which normally closes it under the action of the spring piston, g^1; the auxiliary chamber, *e*, is also in communication with the combustion chamber, *b*, by means of the passage, *h*. A chamber or tube, *i*, connects the auxiliary chamber, *e*, to the combustion chamber, *b*, by small openings, *j* and *k*, respectively. This chamber, *i*, contains the igniter, which, in the form shown in the drawing, comprises a tube, *l*, having the internal swellings or ribs, *m*, *m*, which retain the heat and offer a large surface to the vapor coming in contact with them; *n* is the main air inlet valve and *o* the exhaust valve.

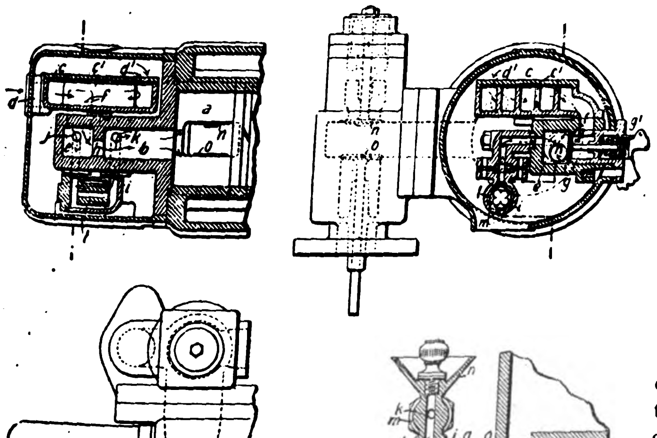


FIG. 4.—DETAILS OF OIL ENGINE.

The action is as follows: The oil entering the vaporizer, *c*, through the inlet, *d*, is, during the suction stroke of the piston, drawn by the air entering through the inlet, d^1, through the vaporizer, and thence through the valve, *g*, into the auxiliary chamber, *e*, where it divides, the major portion of it being drawn directly to the combustion chamber, *b*, whilst the remainder flows through the tube or chamber, *i*, into the combustion chamber, *b;* this latter portion on the following compression stroke of the piston ignites and explodes the charge in the combustion chamber. To start the engine a blow-lamp is placed under the vaporizer and igniter, which it brings to a sufficient temperature in eight to twelve minutes. A little paraffin is then poured into the starting cup, *E*, at the cylinder end, and the air valve being opened, the engine is pulled round. The charge from the cup is thus drawn into the vaporizer, and after a few revolutions the engine starts up. The starting lamp may then be removed. A section of this cup and starting valve is given by Fig. 4. *A* represents the vaporizer and *a* the plug which has a longitudinal passage, *b*, closed by a valve, *c*, formed on a sleeve, *d*, and kept closed by a spring, *f*. The outer face of *a* on this sleeve is open to the atmosphere by the passage, *j*, formed through the flange, *i*. d^1, d^1 are peripheral openings formed at the end of the sleeve cap, *d*, for the escape of the oil into the vaporizer. *o* is a passage through the flange, *i*, for placing the space, *p*, around the plug in communication with the atmosphere so as to permit air to be drawn into the vaporizer around the plug. The action is as follows: The oil being supplied to the plug passage, *b*, and the engine started, air is drawn through the passage, *o*, and around the inner end of the plug, *a*, the suction lifting the sleeve valve, *e*, from its seat against the action of the spring, *f;* the lifting of the valve, *e*, from its seat brings the peripheral holes, d^1 in the sleeve into communication with the plug passage, *b*, whereby the oil coming through the openings is immediately picked off and drawn into the engine with the ingoing air. The quantity of oil admitted may be regulated by adjusting the quantity of air entering with the oil, or by a spindle which fits into the passage through the plug and the front end of which is made conical to fit the inner end of the passage, which is also made conical and forms a valve seat; by turning this spindle, a portion of which is screw-threaded and fits into a nut, the conical portion can be adjusted in position in the conical end of the passage, so as to partially or wholly cut off the oil supply.

The engine runs very steadily and regularly, and may safely be left without attention for comparatively long periods. The igniter, doubtless because the charge it contains is always the same and is independent of the ultimate mixture in the cylinder, is very trustworthy. It retains so much heat that an engine may be stopped for many minutes and will start again without the use of the lamp. It is to be observed that from the position of the igniter and the arrangement of the passages the inert gases are sucked out and replaced by a new charge each time, and that under no circumstances can cold air be drawn into the igniter. These points are essential to its accurate working. The air valve is placed over the exhaust valve in order to reduce complication and to make the latter easy of access. A good point about the construction of these valves is the provision of piston bearings with enclosed springs.

Double-Current Generator.—Figs. 5, 6, 7 and 8, taken from the London *Electrician,* illustrate the details of the 600-kw., double-current generators at the Trafford Park power station. The machine has 20 poles, the pole-pieces being laminated. They carry both shunt and series field windings, so that the generator may run shunt or compound at will. The shunt current is taken from the station bus-bars. The armature is of the slotted drum type and is built up of 15 segments, each of which consists of 774 stampings 0.5 mm. thick and of 6 end stampings 2 mm. thick. The effective width of the armature is, therefore, 399 mm. Each stamping is insulated by a layer of silk paper 0.02 mm. thick, and in order to further increase the resistance along the path of eddy currents a layer of packing paper 0.25 mm. thick is inserted between the stampings in distances of about 20 mm. As will be seen from Fig. 5, which shows the elevation and semi-sectional side view of the generator, two radial air ducts assist in the cooling of the armature. When built up the diameter of the armature comes to 2300 mm. Each armature segment has 31 slots and an air slot at each end, amounting for the whole periphery to 480 slots, the form and dimensions of which are given in Figs. 7 and 8. The winding consists of 480 form-wound double coils, the bars of which are 3 mm. x 4 mm. bare and 3.5 mm. x 4.5 mm. insulated. The winding pitch is from 1-98-195, and so on. There are 960 segments on the commutator. The construction of the armature spider, with its end plates for clamping the armature segments and for supporting the ends of the coils, as also the method employed in building up the commutator and the slot rings, is clearly shown in Fig. 6. The brush rocker required for the direct-current side is supported by four brackets, while that for the alternating-current side is supported from the bearings. Carbon brushes are used on the commutator and copper brushes collect the alternating current. The generator is directly coupled to a Browitt & Lindelly 1000-h.p. engine running at 180 r.p.m. Its normal capacity is 600 kilowatts for either direct or alternating current, or both, simultaneously. Three-phase current is generated at from 325 to 355 volts, regulated by field resistances, and at a frequency of 30 cycles per second. The guaranteed maximum temperature rise in any part of the machine on eight hours' test at full load is 70° F. The specified efficiency at full load is 95.5 per cent, and at half load 93.5 per cent.

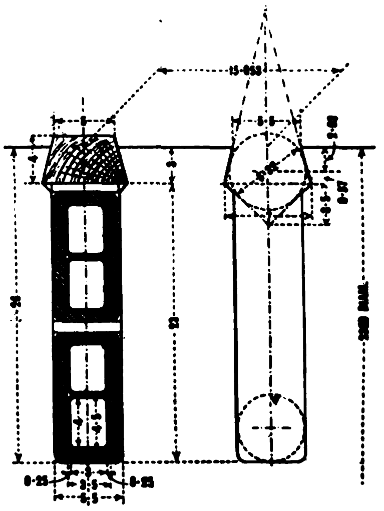


FIG. 7.—ENLARGED SLOT.

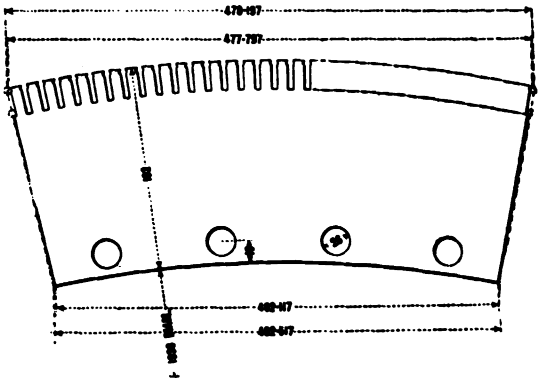


FIG. 8.—ARMATURE STAMPING.

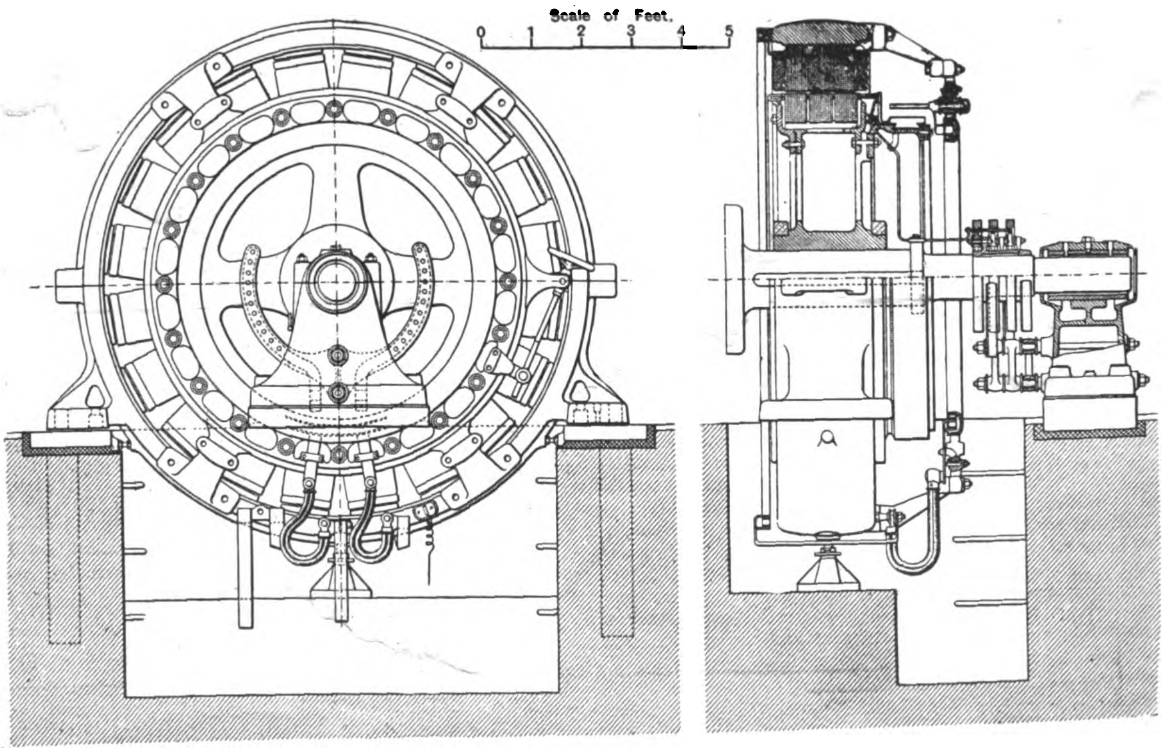


FIG. 5.—ELEVATION AND SEMI-SECTIONAL SIDEVIEW OF DOUBLE-CURRENT GENERATOR.—FIG. 6.

Double Acting Boiler Feed Pumps.—The *Mechanical Engineer* describes a double acting feed pump designed by C. Caille, of Le Perreux, France, a sectional elevation of which is given in Fig. 9 herewith. Referring to the illustrations, the pump cylinder *F* is provided at its lower end with a spring closed discharge valve *C*, admission to the cylinder taking place through an annular recess and a circle of openings *O*. Above this circle the pump cylinder is prolonged into a cylinder *A*. The piston *P* in its downward stroke acts simply as a piston, while in its upward stroke it acts at the same time as a piston and the movable barrel of a pump. It is made in the form of a hollow vessel, its rod *B* being led through a projection *D* of the cover *E*. This projection nearly fills up the hollow of the piston, but between it and the piston there is an annular space *K*. A casing *J* encloses the pump cylinder forming around it a chamber *L* (Fig. 9), which communicated with the atmosphere by means of a pipe *T*, which pipe is raised above the level of the water in the feed reservoir. This chamber does not communicate with the discharge passage *G*. In this latter is placed a spring loaded valve *M*, which separates it from the hollow *H* of the piston *P* and chamber *N*. A pipe *Q* in communication with the atmosphere is led away from this chamber but is separated from it by a floating valve *R*. The water coming from the feed reservoir enters the apparatus by the pipe *I* (Figs. 11 and 12) and fills the chamber *L*, whence it rises in the pipe *T* up to the level of the water in the reservoir. Suppose the mechanism to be in the position shown in Fig. 9. The piston *P* is at the top of its upward stroke, and the hot water with which the chamber is filled descends through the openings *O* into the pump cylinder *F*. The air bubbles and steam produced from the hot liquid escapes into the pipe *T*, where they condense. When the piston in its downward stroke covers the openings *O*, the forcing of the water in the cylinder of the pump takes place through the pipe *G* on account of the valve *C* being pressed down. When the piston is at the end of its stroke, the upper edge of the hollow piston uncovers the opening *O*, and the hollow becomes filled with hot water in the same way that the pump cylinder *F* was filled. The water flowing in also fills the chamber *N*, while the steam formed can escape into the pipe *Q* through the floating valve *R*, which now falls away from its seating by the action of its own weight. Directly the piston *P*, in rising, again re-covers the openings *O*, it forces the water from the hollow *H* and the chamber *N*. The sectional area of the annular space *K* is equal to the opening of the valve *M;* this opens and the liquid forced during the upward stroke escapes through the pipe *G*. The floating valve *R* shuts, by the buoyancy of the water, immediately the chamber *N* is entirely filled with water and freed of steam.

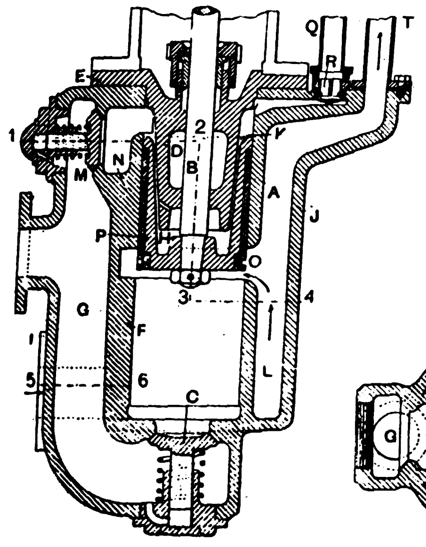


FIG. 9.

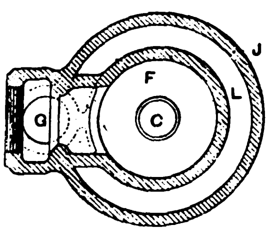


FIG. 10.

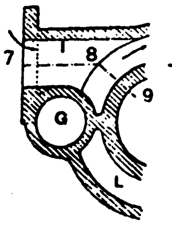


FIG. 11.

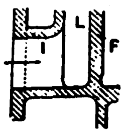


FIG. 12.

SOME RECENT ELECTRICAL PATENTS

Power Factor Indicator.—Fig. 1 herewith illustrates a simple form of power factor indicator which has been patented by William H. Pratt. The instrument comprises two current coils, 1 and 2, which are connected in series with the load or circuit, and two potential coils, 5 and 6, which are connected across the circuit, the latter coil being connected in series with a non-inductive resistance, 8, and the former being divided into two parallel sections, one in series with a condenser 10, and the other in series with an inductance 11. This coil, 5, is a continuous winding with a tap brought out from its center to one of the main line wires and the two free ends connected to the condenser and inductance coil, as indicated clearly in the diagram. The condenser and inductance coil are so proportioned that the currents flowing in the two halves of coil 5 differ in phase practically 180°, the current in one-half being retarded about 90° by the inductance coil, and that in the other half being advanced to a corresponding extent by the condenser. The current in the coil 6 is practically in phase with its e.m.f., the inductance of the coil being negligible and in series with a relatively high non-inductive resistance. Since the flow of current in the two halves of coil 5 is differential, and the two currents differ by 180° in phase, their magnetic effect is cumulative, and the common field set up by them is about 90° displaced from the field set up by the coil 6, in time phase. When current is passed through the instrument, the spindle, of course, takes up a position in which the turning moments of the two windings, 5 and 6, are balanced against each other in the field set up by the coils 1 and 2. When the current in the main line is in phase with the e.m.f. across the circuit, this position of equilibrium will, of course, be established when the windings, 5 and 6, are in precisely the same physical relation to the coils 1 and 2. Should the current in the main circuit lag behind the e.m.f., its phase will approach more nearly to that of the field set up by the divided coil 5, and the spindle will, of course, be turned to a position more favorable for this coil. The same result is produced when the current in the main line leads the e.m.f., so that the instrument does not indicate whether the difference is due to lagging or to leading currents. Moderate changes in frequency do not affect the readings of the instrument for the reason that such a change will give an increase of current in one-half of the coil 5 and reduce the current in the other half to approximately the same extent, so that the resulting ampere-turns of the coil will remain practically unchanged throughout such moderate variations in frequency. Patent 730,397.

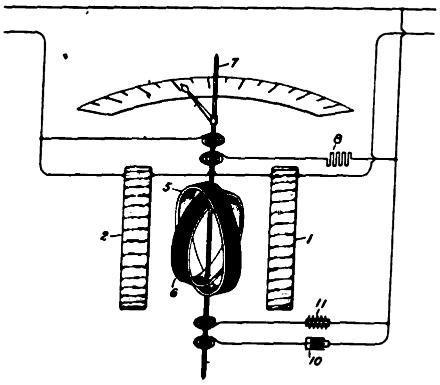
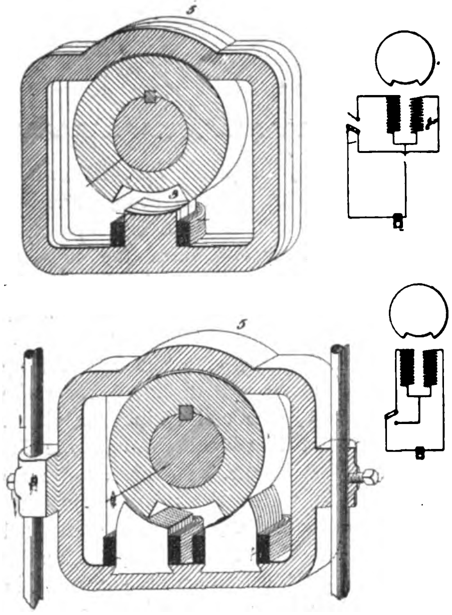


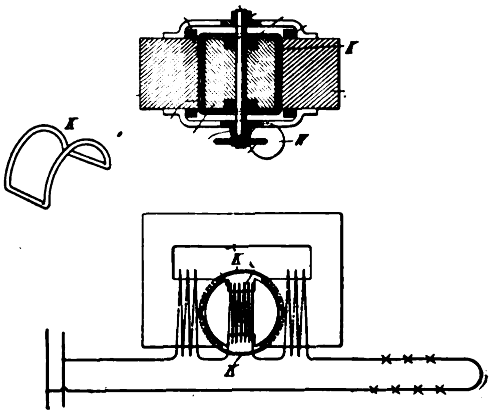
FIG. 1.—POWER-FACTOR INDICATOR.

Gas Engine Igniter.—Figs. 2 and 3 herewith illustrate diagrammatically a very simple form of igniter dynamo for use in conjunction with internal combustion engines, which has been patented by Albert F. Ganz. The machine consists of a permanent magnet, 5, with either a single projecting pole, as in Fig. 2, or two poles as in Fig. 3; in the latter case, the two projecting poles are of the same sign, the curved portion at the upper part of the frame constituting the pole of opposite sign. The machine is merely a small alternator of the well-known inductor type. The projecting pole or poles may be formed integral with the hard steel frame, or consist of laminations set in, as in Fig. 3. The rotating part serves merely to increase and decrease the reluctance of the path between the opposite poles of the frame, as in the case of the inductor alternator. The inventor uses two coils, whether there be two projecting poles or only one, and the patent describes two methods of using these coils. In Fig. 2, the two coils are wound on a single pole, and one is of much smaller wire than the other; a three-point switch is provided which puts in the coil of fine wire and many convolutions when the gas engine is first started up, and as it approaches full speed the switch is thrown over and the coarse wire coil is put into operation. The object of this arrangement, of course, is to provide a high e.m.f. per revolution when the engine is first starting and reduce this to the normal figure as it approaches full speed, the inductor of the igniter being either mounted directly on the gas engine shaft or driven by it. In Fig. 3 the two coils are wound one on each pole, and the connections are such that at starting both the coils are in operation in series, and after the engine has speeded up one of them is thrown out. The inventor refers to the revolving member as being made of steel and the magnet as being "a single casting," but it is quite obvious that the magnet would need to be of tempered steel and the rotor or inductor of the softest grade of iron. Patent 732,346.



FIGS. 2 AND 3.—ELECTRIC IGNITER.

Alternating-Current Circuit Regulator—Another form of automatically-variable reactance coil for regulating series alternating-current circuits has been devised, as indicated by Figs. 4 and 5 herewith, which are reproduced from a patent issued to C. C. Chesney and W. J. Lloyd. Fig. 5 is a diagram of the connections, and Fig. 4 a horizontal axial section of the regulator. It consists fundamentally of a simple bipolar magnet, the exciting coils of which are connected in series with the work circuit (or to the terminals of a shunt block, such as is used with shunted ammeters). The armature, which is of the old Siemens H or shuttle type, is provided with a single coil, and this is in series with the field winding. It is obvious that with current flowing in the windings the tendency of the apparatus is to turn the armature to the position shown in the engravings. This is opposed by a weight (*W*, in Fig. 4), which tends to turn the armature to the position of minimum reactance. The operation is practically the same as that of the other automatic reactance coils in use. When there is no current in the line, the weight sets the armature in the position of minimum reactance, and as soon as the circuit is closed the magnetic torque pulls the armature around, increasing the reactance, and therefore reducing the current, until equilibrium is attained between the magnetic force and the pull of the weight. A third winding is provided, this being two simple closed circuits, the conductors of which are shaped as shown at *K*, and located in shallow slots across the pole-faces. The function of these loops is to neutralize the self-induction of the armature as the latter turns toward the position 90° displaced from that shown in the engravings. Patent 731,430.



FIGS. 4 AND 5.—ALTERNATING-CURRENT REGULATOR.

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A NEW METHOD OF OBTAINING CONSTANT CURRENT

BY F. HARDIE JEANNIN.

There are three effective methods of obtaining constant direct current and varying the supply voltage with the load; (1) varying the armature speed; (2) varying the strength of the dynamo field; (3) varying the effective number of conductors on the dynamo armature. So far regulation for constant current has been secured by an external controlling apparatus. A combination of dynamos was recently patented by the writer, which is absolutely automatic within itself, involving the second method of control mentioned above. In this system the magnetization of the dynamos should be as nearly a straight line as possible between working points, and hence relatively large air gap reluctance is desirable. The accompanying diagram shows the arrangement as illustrated in the patent. Two machines are used, a main generator, similar in construction to any ordinary shunt-wound dynamo, and a regulating machine of similar construction but of comparatively small size. These machines are connected in series with each other and are regulated by means of regulating windings supplied from a circuit connected across the leads joining the two machines. In one of these leads are connected the constant current translating devices.

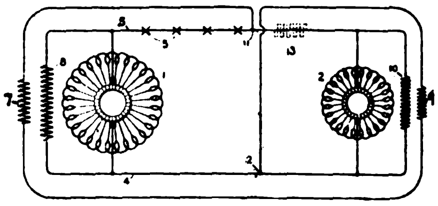

FIG. I.—DIAGRAM OF CONNECTIONS.

Referring in detail to the drawings, the main machine is indicated at 1 and the regulating machine at 2. Each machine is provided with an armature winding and a commutator upon which bear the usual brushes. Unlike terminals of the machines are connected together so as to join the machines in series with each other, these connections being formed by the leads 3 and 4. In series with one of the leads, as for example the lead 3, translating devices 5 may be connected. Across the leads 3 and 4 is connected the regulating circuit 6, including in series a regulating winding, 7, acting in conjunction with the shunt winding, 8, of the machine, 1; and also a regulating winding, 9, co-operating with the shunt winding, 10, of the regulating machine, 2. One terminal of this regulating circuit is connected at a point, 11, in the lead, 3, between which point and the main machine, 1, is the consumption circuit of the system. The other terminal of the regulating circuit is connected as at 12 to the other lead, 4.

In explaining the operation of the system above described, let it be supposed that all the translating devices, 5, are cut out of circuit. Under these conditions the electromotive forces of the machines, 1 and 2, combine to produce a flow of current through the machines and their connecting leads, 3 and 4. The circuits are so adjusted under these conditions as to produce zero difference of potential across the terminals, 11 and 12, of the regulating circuit, 6. To produce this adjustment various factors, of course, may be changed. The principle of the adjustment, however, is that the electromotive force of the machine, 1, should bear the same relation to the resistance of its circuit between the points 11 and 12, as the electro-motive force of the machine, 2, bears to the resistance of its circuit between the same points, 11 and 12. If the resistance of the circuit of the regulating machine should require to be varied, this may of course be done by resistance in series as indicated by dotted lines at 13.

With the adjustment of the circuits as described above, it is evident that the electro-motive force of each machine is consumed in the circuit of said machine between the points 11 and 12, the difference of potential between these points being therefore zero, as already mentioned. Suppose now a lamp to be turned on in the consumption circuit, 5. Under these circumstances the resistance of this branch of the circuit is increased, thereby causing a difference of potential to arise between the terminals of the regulating circuit, 6. Current then flows in the regulating winding, 7, of the machine, 1, thereby raising the electro-motive force of the machine until its electro-motive force again bears the same proportion to the resistance of the circuit between the points 11 and 12, as that which exists between the electro-motive force and resistance of the machine, 2, and its circuit. When this condition is reached, current ceases to flow in the regulating circuit, 6. Any increase in electro-motive force of the main machine, 1, above that necessary to bring the system back to a condition of equilibrium would of course be prevented by the fact that such increased electro-motive force would cause a reversal of current in the regulating circuit, 6, thereby acting upon the regulating winding, 7, of the machine, 1, so as to reduce its field strength.

In the foregoing description no reference has been made to the operation of the regulating winding, 9, on the machine, 2. This winding is not strictly necessary in order to secure regulation, but it is used for the purpose of hastening the regulating action of the system. This regulating winding, 9, is similar in its action to the regulating winding, 7, and acts in conjunction with the shunt field, 10, of the machine, 2, to which it is applied. The resistance of the circuit of the machine, 2, being constant, and the final voltage of the regulating machine, 2, also constant, the machine, 1, is constantly regulated by its winding, 7, so as to have a voltage proportional to the drop of potential in its circuit between the points 11 and 12. In other words the voltage of the consumption circuit, 5, varies in substantially the same proportion as the variation of the resistance of such circuit. A practically constant current in the consumption circuit therefore results.

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NOTES.

Stationary Engineers' Outing.—Rhode Island Chapter No. 2, of the National Association of Stationary Engineers held its eighth annual dinner and outing at the Hauteriere Club grounds just outside Pawtucket, on July 26th. The outing was a huge success and the attendance was surprisingly large considering the threatening weather conditions.

Municipal Electricians' Convention.—The annual convention of the International Association of Municipal Electricians will be held at the Hotel Rudolf, Atlantic City, N. J., September 2nd to 4th inclusive. Among the many interesting features of the convention will be included demonstrations of the Cooper Hewitt mercury vapor lamp and static converter. A demonstration of the De Forest wireless telegraph system is also promised.

Invitation to Manufacturers.—During the period preceding the opening of the Exposition at St. Louis, and while the Exposition is in progress, it is anticipated that many manufacturers will visit the city, and the St. Louis Manufacturers' Association at a recent meeting unanimously decided to make a special effort to give visiting manufacturers opportunities of inspecting the industrial plants in that city and otherwise enjoying their stay. The association, therefore, has requested the AMERICAN ELECTRICIAN to extend on its behalf to all manufacturers reached by this paper a cordial invitation to make full use of all the facilities of the association while in St. Louis.

Governor Drives for Corliss Engines.—In a short but interesting paper recently read by Mr. A. H. Eldredge before the American Society of Mechanical Engineers, the author discussed with appropriate vigor the archaic belt drive commonly used for Corliss engine governors, and described the conspicuous improvements that resulted from changing three large Corliss engines from belt drive to positive drive between the main shaft and the governor spindle. As the author stated at the close of the paper, "there is no excuse for the governor belt." He might reasonably have gone farther and stated that its continued use, in the light of past experience, falls little short of being reprehensible.

Central Station Pumping at Grinnell, Ia.—The Grinnell (Iowa) Electric & Heating Company recently put in a 15-h.p., 500-volt General Electric motor at a pump-house located on the banks of a reservoir about one mile from the power-house. This motor is equipped with an automatic starter, so that the motor can be started from the power-house by simply throwing the main switch on that circuit. The motor is belted to a Goulds triplex pump, with one reduction gear on the pump, and the latter supplies soft water for manufacturing purposes. The Grinnell Electric & Heating Company recently inaugurated a 500-volt, direct-connected day power circuit, and the soft water pumping is done in connection with this day service.

The Association of Edison Illuminating Companies will hold its nineteenth annual convention at The Frontenac, Thousand Islands, N. Y., September 8th to 10th inclusive. A number of valuable papers are in course of preparation on subjects pertaining to the business of the member companies, and already there are indications that the coming convention will probably be the most valuable of the series. The Edison conventions are noted for their close attention to business, the absence of junketing and the beneficial results to its members. The place of meeting this year is selected because of the absence of outside allurements, with the expectation that this meeting will even surpass previous conventions in the strict attention to work for which the Edison Association has always been noted.

The Use of Electric Motors.—We are indebted to the Westinghouse Companies' Publishing Department for the following information concerning the increasing use of electric motors. Exclusive of those used for railways, automobiles, elevators and fans, there are over 60,000 motors, ranging from ⅛ horse-power to 2,000 horse-power, in daily operation in the United States, supplying over one million horse-power, and representing an investment of about twelve million dollars. The Westinghouse Electric & Manufacturing Company records one instance where thirty steam engines of 1,375 aggregate horse-power were supplanted by fifty-seven motors of 1,065 total horse-power, for machine shop driving; the average daily saving in steam was 41.6 per cent, and of combustible 32.2 per cent. In other cases electric driving has reduced by 50 per cent the expense for attendance, coal and water; the fuel account 20 per cent, the cost of power 44 per cent. The gross saving was 30 per cent with direct-connected motors, and 22 per cent with belted or geared motors. The application of electric motive power for machine shops, except in special instances, is steadily superseding that of steam, compressed air, hydraulic, rope drive, or combinations of these powers. Within the past ten years the use of electric motors in shops has risen from a few incomplete and scattered cases to the present employment of about 600,000 horse-power regularly supplied by electricity. As a factor in this industrial advance, the Westinghouse Electric & Manufacturing Company has, of course, occupied a prominent and important place.

Convention of the National Electrical Contractors' Association.—The third annual convention of the National Electrical Contractors' Association took place at Detroit, Mich., July 14, 15, 16 and 17. Much enthusiasm was shown, and while the meetings are not yet taken up with the discussion of papers on technical subjects, practical affairs are talked over and the general interests of the contractors are safeguarded thereby. The Detroit Light Guard Armory was none too large for the exhibit of electrical apparatus put in use by the electrical contractor, and over fifty manufacturers took advantage of the opportunity to display their various lines.

On the opening day the arrival of the Eastern delegation in the early morning was attended by some amusing exercises and a mock parade. An executive session of the directors was held at 10 o'clock, at which a nominating committee was selected. At 2 o'clock the convention went into open session and the delegates were formally welcomed to the city by Mayor Maybury, who extended the freedom of the city to the delegates, and called attention to the fact that Thomas A. Edison was once a Michigan lad, who took his first lesson in the craft as a messenger boy between his home, Port Huron, and Detroit. President Charles L. Eidlitz responded. Immediately following the speeches, the convention again went into executive session and all the proceedings were conducted in executive session, so that no report can be given of the transactions. The officers elected were Earnest McCleary, Detroit, president; first vice-president, W. I. Gray, Minneapolis, Minn.; second vice-president, W. C. McIntyre, Philadelphia, Pa.; treasurer, J. R. Galloway, Washington, D. C.; secretary, W. M. Morton, Utica, N. Y.; sergeant-at-arms, J. C. Stearns, Buffalo, N. Y.

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

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CONTENTS.

Modern Railway Power Station and Sub-stations, by W. G. Viall ... 387
Internal Separators for Steam Boilers, by R. T. Strohm ... 393
Telephone Engineering, by F. J. Dommerque ... 394
Liquid Fuel, by C. L. Hubbard ... 396
Convention of the American Institute of Electrical Engineers ... 398
An Oil Engine Central Station, by H. S. Knowlton ... 404
Alternating Current Motors for Variable Speed, by W. I. Slichter ... 407
Abstracts from Foreign Contemporaries ... 408
Some Recent Electrical Patents ... 411
New Method of Obtaining Constant Current, by F. H. Jeannin ... 412
Notes ... 413
Editorial ... 414
Design for a One Horse-power Self-starting Single-phase Induction Motor ... 416
Intercommunicating Telephone Systems, by A. D. O'Brien ... 418
Simple Prony Brake ... 420
Alternating Current Wiring, by C. P. Poole ... 421
The Hot-well as an Oil Extractor, by A. H. Eldredge ... 425
The Boiler Blow-off, by W. T. Edwards ... 425
Lessons in Practical Electricity ... 426
Letters on Practical Subjects ... 428
Questions and Answers ... 429
Voltmeter Compensator ... 430
Heating and Ventilating Equipment ... 430
A Large Commutator ... 430
New Apparatus and Appliances ... 431
New Books ... 433
National Electrical Contractors Association Convention Notes ... 434
Obituary ... Adv. 51
Personal ... Adv. 51
Trade Publications ... Adv. 51
Business News ... Adv. 52

Breakdown Precautions in Central Stations.

No one who has studied the designs of the larger central stations of the day can fail to be impressed with the more than ordinary provisions made for preventing the spread of trouble in case of a breakdown at any one point in the station. Each large station usually marks some advance over its predecessors in the completeness of possible isolation of one part of the plant from another. In some of the most recent stations this provision for sectional isolation extends from the boiler-room to the outgoing, high-tension transmission lines. The weak points—those at which the spread of trouble is most likely to occur—are admittedly the steam piping and the high-tension bus-bars over which the output of the various generators passes. Precautions taken to prevent high-tension short-circuits from establishing arcs, which would jeopardize the service on all the lines in the station, are elaborate and imposing. They consist in surrounding each bus-bar with a masonry wall for its entire length, and isolating the switches, or even the poles of each switch separately, in a similar manner.

It has been pointed out recently, however, that in a large station there is more liability to interruption of service by breaks in the steam piping than by trouble on the high-tension circuits, as they are at present constructed inside the stations. In a recent discussion by the Chicago branch of the American Institute, it was stated that three-fourths of the interruptions to service recorded by the Chicago Edison Company were due to mechanical troubles within the station; and it was intimated that the steam piping was the weakest link in the chain of energy conversion and distribution. Recognizing this, the designers of the mammoth new station in Chicago have arranged that the steam piping for each steam turbine unit shall be as completely isolated from the remainder of the station as are the high-tension circuits and switches. It is but logical that electrically-operated valves should be employed in this connection, and this will be done in the new station. Unless some means of controlling steam valves from a distance is used in a station, it is useless to expect that steam piping troubles will not occasionally cause a great deal of annoyance, and even shut-downs. It is desirable, and usually imperative, in order to secure flexibility of operation, that there must be some steam-pipe connections between one portion of the station and another. If these connections are open, it may become impossible to close them when there is a break in the steam piping, because of the escaping steam and hot water. The only remedy is either to isolate different parts of the station permanently, which is usually not feasible, or to put in valves which can be controlled from a distance.

Valves of this type need not be numerous in a station, but there should be enough of them to insure against interruptions due to the cause just mentioned. The electrically-operated valve is such a simple piece of mechanism that it is not easily crippled, and on the whole it will usually be found more practical than a mechanically-operated valve with shafts, rods and levers allowing it to be operated from a distance. It has been argued against valves fitted for distant control that they are likely to be out of order if used only in cases of emergency. It goes without saying, however, that they should be worked at regular and frequent intervals, whether this be necessary or not; that is practically the only way to insure their being in working condition at critical times.

The Choice of Alternating-Current Frequency.

Among the many interesting papers read at the Niagara Falls convention of the American Institute of Electrical Engineers was one by Mr. Paul M. Lincoln on the choice of frequency for very long transmission lines, in the course of which the author pointed out the advantages obtainable from the use of low frequencies for transmission lines. Numerical examples were given which indicated that the amount of power that can be transmitted over a three-phase line 200 miles long is about two and one-half times as great with 25 cycles as with 60 cycles, for the same degree of voltage regulation. Concerning the condenser effect of the line, he stated that if such a line were supplied at 60 cycles, the generators would have to run at practically full-load current all the time, regardless of the actual load, on account of the charging current taken by the line. Of course, these facts were all known in a general way before, but they have not been presented in quite such startling figures before.

Since the condenser effect of a line, like its inductance, depends upon the distance between the wires, the closer the wires are to each other the lower will be the capacity. But the wires of a transmission line must be kept far enough apart to prevent disaster from leakage and brush discharges, and Mr. Lincoln naturally based his figures on distances which practice has shown to be the minimum allowable in each case. The only practical method of reducing the condenser effect of any modern transmission line, therefore, would be to reduce the frequency. But, as was pointed out by several engineers in the discussion of Mr. Lincoln's paper, the frequency for any transmission line cannot be determined regardless of the apparatus to be connected to the line. So far as the line, and even the generating apparatus, is concerned, the lower the frequency the better; except for the nuisance of having to use raising transformers in the power-house of a high-tension plant (20,000 volts or over), there is no reason why the frequency could not be brought even as low as 10 cycles at the generator and increased by frequency-changers at the receiving stations. So long as raising transformers must be used, however, it would appear that 30 cycles is thus far the best generator frequency for long-distance high-tension plants, frequency-changers being used between the main system and whatever arc lighting systems may be supplied from it.

As we have pointed out several times in these columns, it seems entirely obvious that 40 cycles is the very best frequency for central station and all other plants not involving long-distance transmission. It is not difficult to operate rotary converters at this frequency, and there is no other translating device now in existence that does not operate with perfect satisfaction at 40 cycles. Of course, so far as operation alone is concerned, the lower the frequency the better, down to 35 cycles for arc lamps and between 25 and 30 cycles for incandescents. But taking everything into consideration, 40 is certainly the most satisfactory figure for all-around conditions in the present "state of the art." The compromise frequency of 60 cycles has the advantage of being too high for smooth converter operation, and in large central station plants of the "district" class it entails serious line inductance.

The American Institute Convention.

It is only with great difficulty that one can muster up sufficient courage to utter a word in criticism of the splendid convention held last month at Niagara Falls by the American Institute of Electrical Engineers. The unusually meritorious character of the papers read (or, rather, presented) there undoubtedly had much to do with the large attendance; more members were present at this convention than at any other in the history of the Institute, and the number of papers—but that is where the criticism comes in. When papers are of high merit it is unfair to their authors to gorge the program so that a reasonable amount of deliberate consideration cannot be given to them; when papers are poor, to make the number of them large is to insure meager attendance and to inflict undeserved punishment upon the faithful few who do attend. The papers presented at the Niagara convention were much above the average in both engineering merit and freedom from exploitation characteristics, but the number of them was sufficient to supply daily sessions for a solid month. The skill with which the program was handled, however, prevented this embarrassment of riches from producing anything like the perfunctory consideration that would ordinarily have resulted. All the papers of a given class were presented and discussed together, and those particularly interested in any of the classes of work covered at this convention were thus enabled to get all the papers and discussion in that class by attending the one or two sessions devoted to that group. The program was also facilitated by the marvelous degree of tactfulness with which President Scott kept the discussions along a straight line.

Coal Supply for Central Stations.

Speaking on the subject of the tendencies of central station development, Mr. W. L. Abbott, chief operating engineer of the Chicago Edison Company, recently pointed out the necessity that the large modern stations should guard against shortage in coal supply by providing large storage capacity of their own and even owning coal cars and sidings on which to store them in order to avoid the heavy railroad charges for detained cars and side-trackage. The advice was excellent, and might profitably be taken by smaller stations as a suggestion concerning their own cases. No station operated by steam is so small that its management can afford not to provide relatively ample space and facilities for storing fuel. Even if a carload of coal will last ordinarily a week, provision should be made for keeping several carloads in storage; it would be a very small station, however, that would burn less than two or three carloads a week.

In small cities there is not the danger of delayed delivery due to congestion in railroad yards which is a serious factor in metropolitan coal supply. But there are other causes of delay in delivery which are equally stubborn and serious while "in force," and it is an extremely short-sighted policy to provide merely a few coal bins capable of holding about a week's supply. One of the most practical methods of dealing with this problem, for stations of moderate size, is to provide bins large enough to hold a month's supply, these being built against the outside of the station building proper and at a sufficiently high level to allow the bins to be entirely emptied by gravity feed through chutes to the fire-room. Immediately beneath the storage bins provide a side track for the reception of a coal car, and suitable hoisting apparatus into the buckets or barrows of which to unload the car. The hoisting mechanism is motor-driven, in one case with which we are familiar, and the expense of coal handling is less than half what it was before this arrangement was adopted.

The International Electrical Congress.

As previously announced in our Notes columns, an International Electrical Congress will be held at St. Louis during the Exposition period next year. A preliminary organization was effected recently, and the time selected for the Congress is the second week in September, which week has also been assigned for the annual meetings, at the Exposition, of the various national electrical organizations of the United States, such as the American Institute of Electrical Engineers, the National Electric Light Association, etc. The Electrical Congress will consist of a Chamber of Delegates, which will consider international questions such as units and standards, and a general body, which will be divided into sections representing the main departments of electricity—applied, experimental and mathematical.

It is expected that one or more sessions of each section of the main body will be a joint meeting with one of the several national electrical organizations which will hold their meetings during the Congress week. This appears to be an excellent arrangement for several reasons. A member of one of the national organizations will be enabled to attend both the regular meeting of his association and the International Congress within the single week, and may, by reference to the program, select the section of the Congress before which are to be read the papers that are of most interest to him. Moreover, it is probable that the sessions of the Chamber of Delegates will be so timed that any one who desires may be present to hear discussions by the great authorities who will compose this body, without sacrificing any of the sessions of the main body or of the organization of which he is a member.

DESIGN FOR A ONE HORSE-POWER SELF-STARTING SINGLE-PHASE INDUCTION MOTOR.

The accompanying drawings give all of the essential features of a self-starting induction motor capable of giving one brake horse-power on a single-phase circuit of 100 volts and 125 to 133 cycles. The speed of the machine will depend, of course, primarily upon the frequency of the supply current. The synchronous speed at 125 cycles is 3750, and at 133 cycles it is 4000 r.p.m. The actual full-load speed will be something like 3300 r.p.m. at 125 cycles and about 3500 r.p.m. at 133 cycles.

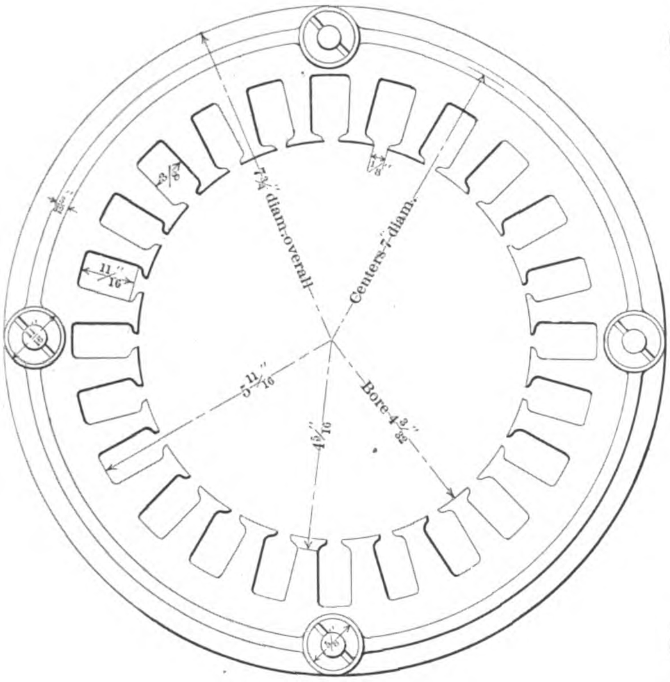


FIG. 1.—END VIEW OF STATOR.

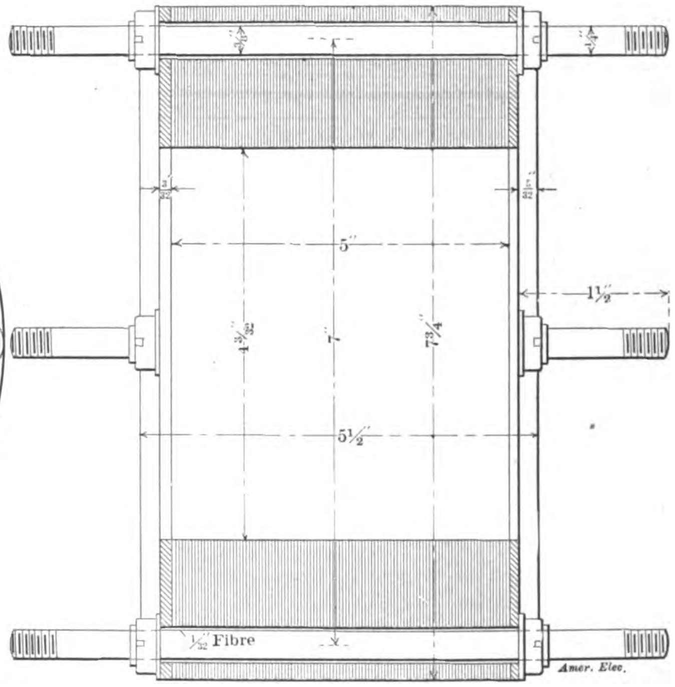


FIG. 2.—AXIAL SECTION OF STATOR.

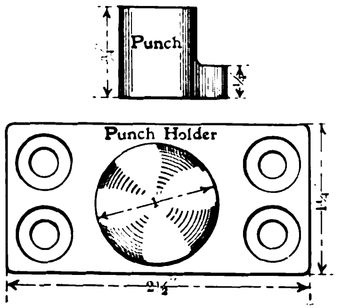
THE STATOR.

Fig. 1 is an end view of the stator and Fig. 2 is an axial section of it, showing the arrangement of the brass end plates and the bolts that hold the structure together. The stator core is built up of 280 discs of sheet steel, each 20 mils thick, and allowing for scale and irregularities, the mass should be drawn together tightly enough to make the axial thickness 5 inches, as indicated in the engraving. The stator discs are 7¾ inches in diameter outside, and the hole in the center is 4 3/32 inches in diameter; this latter measurement must be absolutely exact. The 24 slots around the edge of the central hole are to be punched by means of the simple punch and die shown by Figs. 3 and 4, these being used in a step-by-step notching press. It is not assumed that the builder will possess one of these presses or buy one for the purpose of building this one motor; but he can easily make the punch and die and have the work done at some shop where such presses are in use.

THE PUNCH.

The punch is built up in three pieces, a shank and holder plate of cast iron, a punch pad of ordinary machine steel, and the punch proper, of annealed steel. The punch pad is a simple rectangular plate in the center of which is worked a socket for the punch, the outline of this socket being the same as that of the main portion of the opening in the die. The punch is, of course, of the same outline on its face as the complete opening in the die, and the upper part of it is to be made a very snug fit in the hole in the punch pad. The latter is secured to the punch holder by means of four ¼-in. flat-head machine screws. In machining the holder, great care must be taken to have the face of it absolutely at right angles with the axis of the shank. The wall of the socket in the punch pad must also be precisely at right angles with the face that matches the face of the holder plate.

Fig. 3 shows the punch pad partly unscrewed from the holder, and the punch removed from its socket; it is held in the socket by means of a ¼-in. round-nosed set-screw, and a depression should be machined in the side of the punch to allow the nose of the set-screw to seat itself without having to burr the punch. After the punch has been filed to shape, it must be tempered. In first hardening it, the steel should be heated to a bright red and "quenched" in oil or lukewarm water; if very cold water is used, the steel will be too brittle. The temper should be drawn in the flame of a Bunsen burner, and the steel should be wiped frequently with an oily rag during the heating. If the reader is not familiar with the process of "drawing" the temper of tool steel, he had better get this done by an experienced workman.



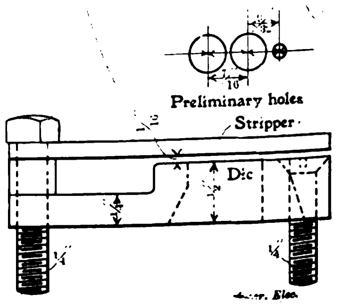


FIG. 3.—PUNCH AND DIE.—FIG. 4.

THE DIE.

The die is to be made of annealed steel, of the quality used for this class of work (any dealer will supply the proper quality if told what it is to be used for). The sketches show clearly the shape and dimensions of the die. The dotted-line arcs indicate the inner and outer edges of the stator disc when in position for punching. The hole in the die may be most readily cut by first drilling two holes ⅜ in. in diameter and one hole ⅛ in. in diameter along a straight line scribed on the face of the die block; the distances from center to center of these holes are stated in the supplementary sketch between the plan view and the side view of the die. Having drilled these three holes, the superfluous metal must be filed away slowly and very carefully until the desired shape of slot is obtained. Then the hole must be enlarged on the under side of the die block in order to give clearance for the small pieces punched out of the stator discs to free themselves.

The die is bolted to the bolster (which need not be made by the amateur, as the shop in which the punching is done will have bolsters from which an appropriate selection may be made) by means of two cap screws and two flat-head machine screws. The cap screws also hold the stripper plate, which is a rectangular steel plate ⅛ in. thick and of the same outline as the base of the die block; it must have a hole cut in it which will come directly over the hole in the die, but the hole in the stripper need not be accurately machined to the shape of the punch; it may be a simple rectangular aperture ⅜ in. wide and 1 in. long. After the hole in the die has been finished to fit snugly about the punch, which must touch *every part* of the wall of the die hole, the die is to be tempered. The remarks concerning the tempering of the punch apply also to the die.

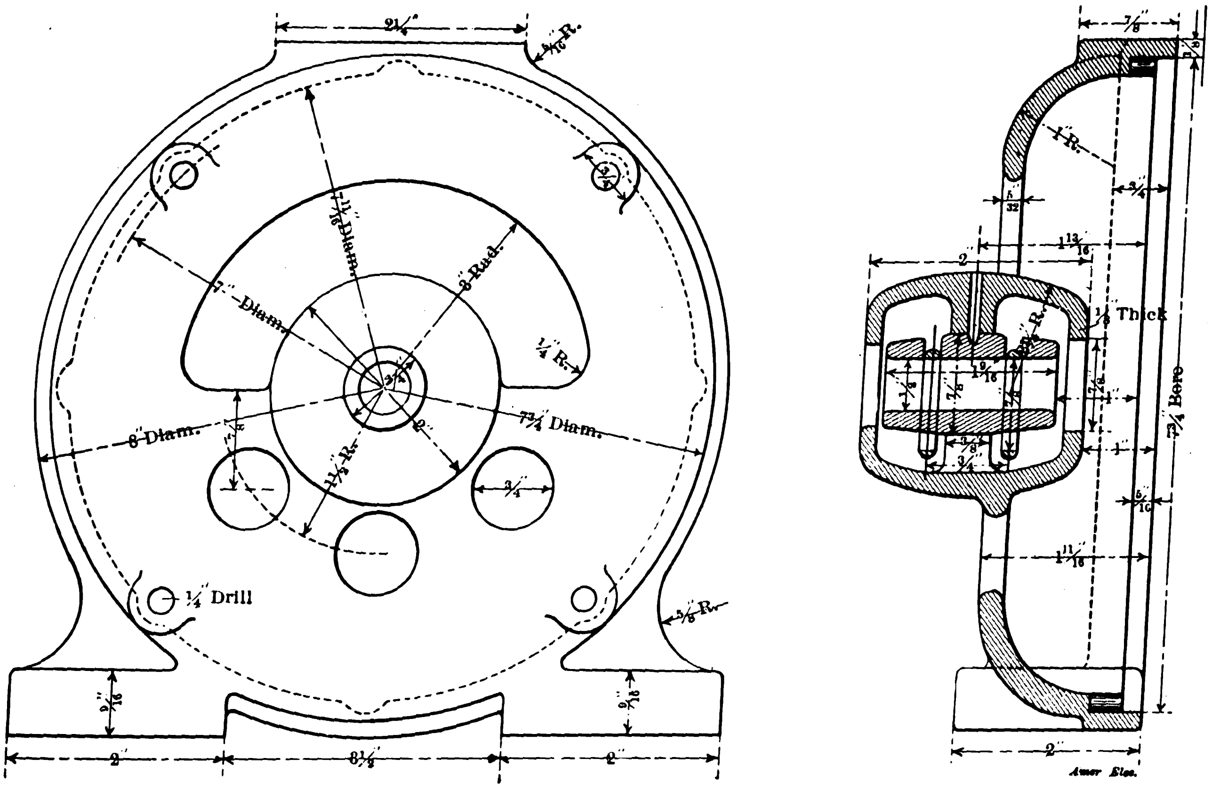


FIG. 5.—ELEVATION AND SECTIONAL VIEW OF ONE END CAP.—FIG. 6.

STATOR CLAMPING PLATES AND ASSEMBLY.

The brass end plates are cast with the slots in them, the sizes of the slots in these plates being a trifle full, as compared with the punched slots in the core discs. It will not do to use a simple brass ring of an internal diameter large enough to clear the slots in the core; the teeth between these slots must be clamped together tightly along with the body portion in order to reduce as far as possible the humming of the machine when in operation. In assembling the core discs between the brass end plates, the structure must be clamped together by means of two heavy cast-iron discs 5¾ inches in diameter and a 1-in. bolt through the center; this work may be facilitated greatly by the use of ordinary iron clamps such as are found in all machine shops, applying these at points around the outer edge of the stator in order to even up the compression and assist the central clamping bolt. After the discs are drawn to position, the holes near the outer edge may be drilled; if the brass end plates have been made of a hard alloy, the top one will serve as a jig for the drill. In this event it should be drilled before assembling the core discs, but the under plate should be left undrilled; when the discs are assembled, the holes may be drilled clear through them and the under brass plate. A much safer plan, however, is to make a cast-iron jig plate and clamp the discs between it and a plain cast-iron plate for drilling; the brass end plates should be drilled by the same jig plate, but separately.

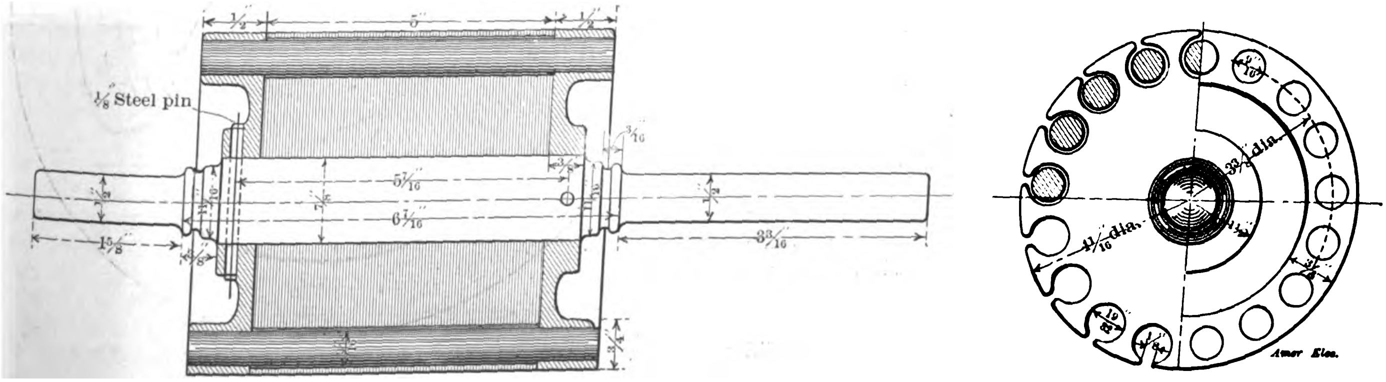


FIG. 7.—AXIAL SECTION AND END VIEW OF ROTOR.—FIG. 8.

JOURNAL BRACKETS.

The four ⅜-in. bolts which hold the stator core together also serve to hold the journal brackets or end caps in place. Fig. 5 shows one of these end caps and Fig. 6 is an axial section through the center of it. The drawings require no explanation beyond saying that the caps are to be made of cast iron. (Figs. 1 and 2 show the stator turned 45° from the position that it occupies when clamped between the journal brackets, or end caps, this being done to show the bolts in the sectional view.)

The journal sleeves shown in the engraving are of the self-aligning type, but if the reader is not very skillful at machine tool work it will be preferable to make them perfectly straight, making the outer diameter of the sleeves ⅞ in. the whole length. No pulley has been shown, as this can be bought for less than it would cost an amateur to make it. The proper size is 3 or 3½ in. in diameter at the crown and 1½ in. width of face.

THE ROTOR.

The rotor is shown by Figs. 7 and 8. It consists of 280 discs of sheet steel 20 mils thick, clamped on the shaft between two cast-brass end plates, which also serve to connect the ends of the rotor conductors. There are 17 of these, each 9/16 in. in diameter and 6 in. long; the holes in the rotor discs are 19/32 in. in diameter, and may be drilled with the aid of two cast-iron plates between which the discs are temporarily clamped, one of the cast-iron plates to be previously drilled so as to serve as a jig for the drill when the discs are drilled.

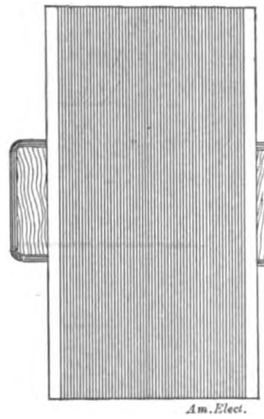


FIG. 9.— WINDING BLOCK.

STATOR WINDINGS.

After the stator is finished the slots and end surfaces of the core should be insulated by means of red rope paper 0.025. in. (25 mils) thick, which should be thoroughly varnished with shellac before being put in place. The main stator winding must not be put on until the starting winding is in place. This winding consists of four coils of No. 11 wire, each having 18 turns. Each of these coils should be wound into the proper slots over two blocks of wood (one at each end of the core) which will cause the coils to project 1 in. beyond the face of the stator end plates, as indicated in Fig. 9. After they are wound in place, these projecting ends are to be bent upward out of the way of the main coils, which must be wound in the slots between those of the starting winding. Fig. 10 indicates this bending upward of the starting coils, and also shows the slots into which they are to be wound. They are connected in series with each other, and the connections must be such that if direct current were passed through this winding it would produce alternate north and south poles within the four coils.

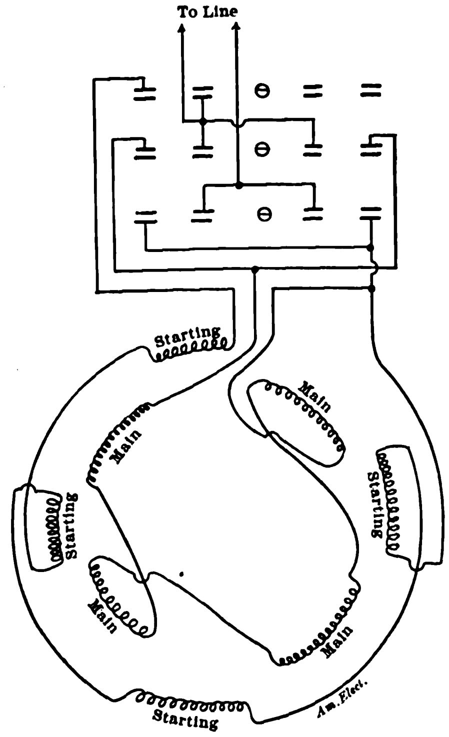


FIG. 11.—STATOR CONNECTIONS.

After the starting winding is in place and connected up, the main coils should be wound into their slots; two thicknesses of varnished muslin must be laid over the exposed parts of the starting winding just before commencing the winding in of the main coils. These main coils consist each of 36 turns of No. 11 double cotton-covered wire, and each coil occupies four slots; they are to be wound in their slots as indicated by the elementary diagram, Fig. 10. The diagram shows only one turn in each slot, but the reader will of course understand that 18 turns are to be wound in the inner pair of slots, *I, I,* before any wire is wound in the outer pair, *II, II,* and that 18 more turns are then wound into these latter slots. The coils of the main winding, like those of the starting winding, must be connected up in series and in such wise that direct current passing through them would produce four magnetic poles of alternate polarity; north, south, north, south. It makes no difference what the relation is between the direction of the starting coils and that of the main coils; the terminals must be carried out to a three-pole, double-throw knife-blade switch, as indicated in Fig. 11, and if the connections at first made do not start the motor in the direction in which it is intended or desired to run, it may be reversed by merely reversing the leads from either the main winding or the starting winding, but not both.

The switch should be mounted so that the throw is horizontal (unless an additional main switch is provided), in order that it may be left open without danger of accidentally closing by gravity. As the diagram is drawn, throwing the switch to the left puts in both windings, for starting up; when the machine attains something like normal speed, the switch should be thrown quickly to the other side, leaving only the main winding in circuit.

If the builder prefers to use simpler apparatus, two ordinary double-pole switches may be used, one for the main winding and one for the starting winding, but this arrangement has the slight disadvantage that the user may close one switch and leave it closed for an appreciable length of time before closing the other, which might overheat the winding thus thrown in alone, as the motor would not start up and the winding would be provided with a short-circuited secondary—the rotor conductors. The result would be similar in kind, though less in degree, to that obtained by short-circuiting the secondary terminals of an ordinary transformer with the primary connected to the supply mains. The motor should not be started with any load on it except the countershaft to which it is belted. Even with that it will be found advisable to give the belt a strong pull, to overcome standing friction, when the motor is thrown into circuit.

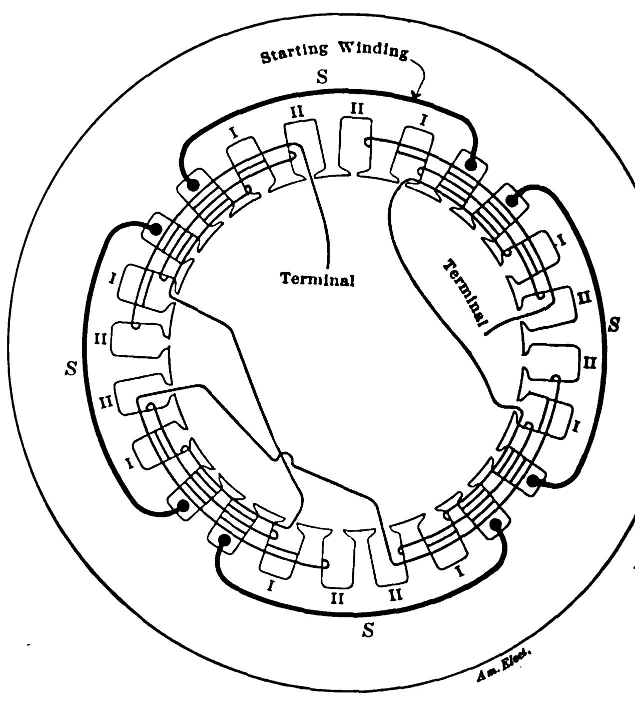


FIG. 10.—STATOR WINDING.

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INTERCOMMUNICATING TELEPHONE SYSTEMS.

The Couch & Seeley Automatic.

BY A. DALLAM O'BRIEN.

The Couch & Seeley Company's automatic telephone system is designed for use in private houses or business establishments where there is necessity for intercommunication between the various room or departments. In this system, as in the majority of systems designed for similar purposes, the automatic switch constitutes the distinctive feature and in this switch are found features rather different from those of the systems previously described in this series of articles. The switches are constructed to be mounted in the interior of the instrument and form an integral part of it in both the wall and desk forms. The switch itself consists of a number of strips of jacks mounted on a metal frame which is fastened to the interior of the instrument. Each jack strip contains five jacks, and in consequence the switches are readily constructed in any desired multiple of five.

The lines from the various instruments are connected to the corresponding line terminals in the switch, the arrangement and number of terminals, or style of jack used, of course depending upon the method of wiring.

Figs. 1 and 2 show the switch construction, Fig. 1 being a section and Fig. 2 showing a front view with the cover plate removed. The style of jack and plunger, or push button, shown in these figures is intended for use with a common return method of wiring. The operation of the switch is as follows: Each jack is provided with a steel plunger, or push button, as shown, the plunger having three collars formed upon it; the outer collar serves to hold the plunger in its normal position with reference to the front plate when the button is not pressed, and the second or middle collar holds the button in its depressed position by engagement with the releasing bar.

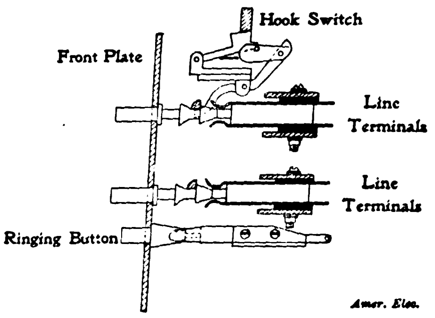

FIG. 1.—CROSS-SECTIONAL VIEW OF SWITCH.

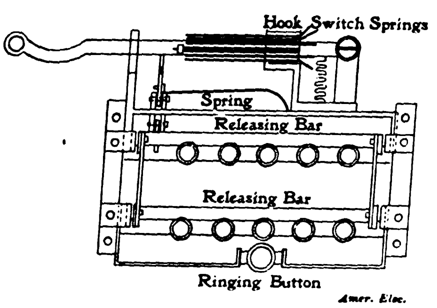

FIG. 2.—FRONT VIEW OF SWITCH.

Where a metallic circuit is used the jack is provided with two inner and two outer contacts, these contacts being brought into metallic connection when the plunger is depressed through the agency of the inner collar, which in this case is made of insulating material. When the instruments are wired for a common return the inner collar on the plunger serves to connect the two springs of the jack. It will be seen from the construction of the switch that the only part of the mechanism exposed to view is the head of the push button which projects through the front plate and appears on the face of the instrument. The hook switch is mounted on and made a part of the switch casing and is arranged to operate the releasing bar. When a push button is depressed, the releasing bar slides over and drops behind the central collar of the plunger and locks it in its depressed position, the receiver in the meantime having been removed from the hook. When the conversation is finished and the receiver hung up, the combination of levers shown in the drawings is operated by the depression of the hook switch, the releasing bar raised, and the plunger, acting under the influence of a spiral spring mounted on the interior of the jack strip, is forced forward and returned to its normal position with its forward collar in contact with the front plate, thus breaking the connection and restoring normal conditions.

In connection with and operated by the hook switch are mounted five contact springs, shown in Fig. 2, these springs serving to close the talking and ringing circuits, as an inspection of the wiring diagrams will show. The automatic switch is also equipped with a ringing button of hard rubber, it being necessary to press this button in order to signal any desired line after the push button of the line in question has been depressed. One releasing bar is provided for each strip of jacks, the bars of the various strips being connected at their ends, as shown in Fig. 2, so that the releasing lever acting on the upper bar serves to raise all the bars.

The instruments are adapted to be wired in a number of ways, as local conditions may require, the standard methods of wiring being as follows: Local talking and central ringing batteries, and a common return wire for all instruments; local talking and central ringing batteries, and a complete metallic circuit for each instrument; the foregoing combinations with the central ringing battery replaced by a magneto generator and polarized bell at each instrument; central ringing and talking batteries, and a common return for all instruments; this last arrangement with a complete metallic circuit for each instrument, and the substitution of a magneto generator and polarized bell at each station for the central ringing battery.

Any desired number of stations may be connected on one line, it being necessary, however, to hold such buttons as have been depressed in the depressed position when connecting additional stations, in order that the operation of the releasing bar may not cut off the connections already completed.

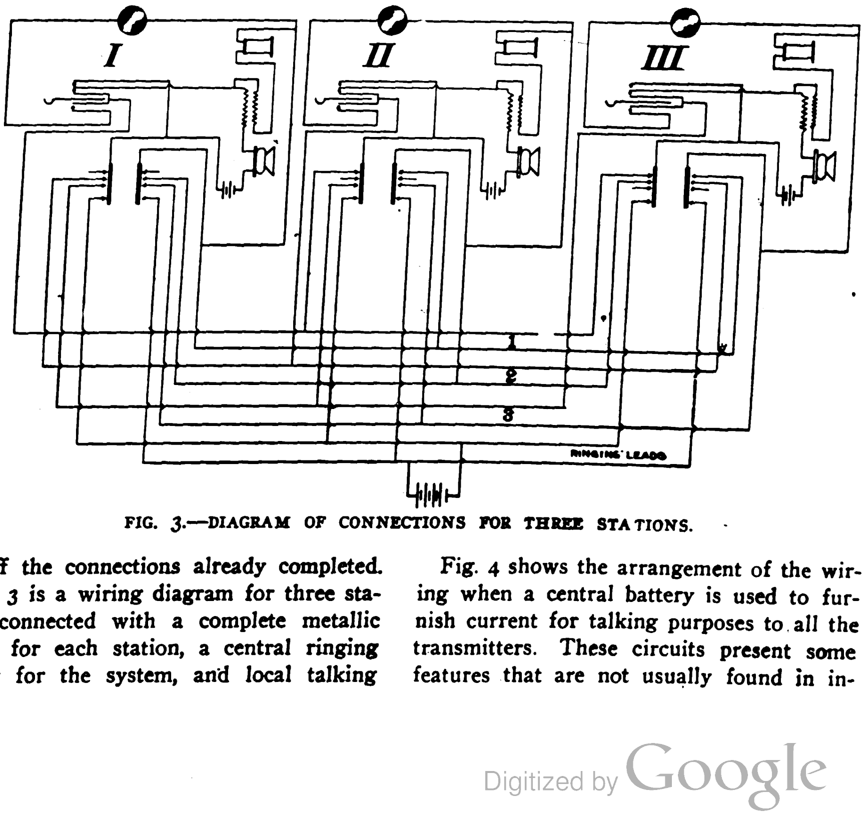

FIG. 3.—DIAGRAM OF CONNECTIONS FOR THREE STATIONS.

Fig. 3 is a wiring diagram for three stations connected with a complete metallic circuit for each station, a central ringing battery for the system, and local talking batteries with an induction coil at each instrument. To illustrate the method of operation, assume that station *I* wishes to call station *III;* button No. 3 of the automatic switch at station *I* is depressed, thus bringing the line springs of the jack in connection with the local springs of the jack, after which the depression of the ringing button allows current to flow from the central ringing battery to the local contacts at station *I,* thence over the line to station *III,* through the lower contacts on the hook switch, through the bell and back over the other side of the line to jack 3 at station *I,* and thence through the local jack contacts and ringing lead back to the battery, thus signalling the required station. The removal of the receiver from the hook closes the three upper contacts on the hook switch, which serve to close the circuit of the local battery through the transmitter and primary winding of the induction coil, and at the same time to connect the receiver and secondary winding of the coil in series in the line.

From the foregoing description, it will be evident that the talking circuit presents no novel features, but is wired in accordance with the usual magneto practice. When the receiver is hung up the connection is broken at the calling station, as has been previously described, by the hook switch. The necessary wiring for this method of connecting instruments consists of two wires for each station running to each other station and in addition, a pair of wires running throughout the system and tapped at each station to furnish ringing current. Any standard type of wet or dry battery may be used for furnishing the necessary current, two cells being sufficient for the local talking circuit and from four to six cells being required for ringing purposes, the number depending upon the length of line over which it is necessary to signal. The bells used in connection with all the various methods of wiring, where a battery is utilized for furnishing ringing current, consist of the ordinary type of low-resistance vibrating bells.

Fig. 4 shows the arrangement of the wiring when a central battery is used to furnish current for talking purposes to all the transmitters. These circuits present some features that are not usually found in installations of this character. As will be seen from the diagram, the receiver at each station is in a closed local circuit with the secondary winding of the induction coil, and this secondary circuit always remains closed.

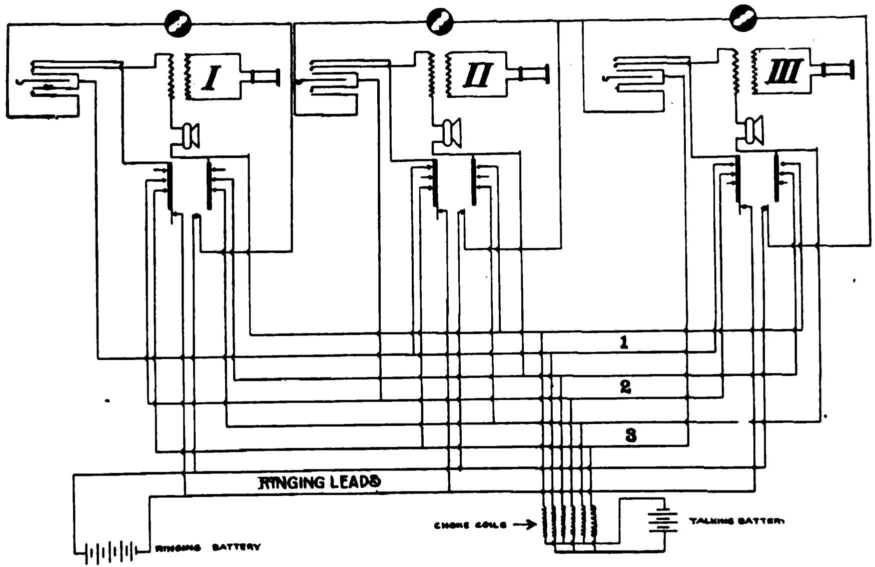

FIG. 4.—DIAGRAM OF CONNECTIONS WITH CENTRAL BATTERY.

The transmitter and primary winding of the induction coil are connected in series with the line through the upper contacts on the hook switch and the local contacts of the automatic switch jacks. The central talking battery is located at any convenient point in the system and provision is made for mounting near the battery a number of retardation or choke coils, two coils being required for each station connected. One end of the winding of a coil is connected to one side of the line, as shown in the drawing, the free ends of the windings being connected to the battery terminals or to bus-bars fed from the battery as may be most convenient. It is evident that the effect of this arrangement is to bridge the battery across each line through a pair of retardation coils.

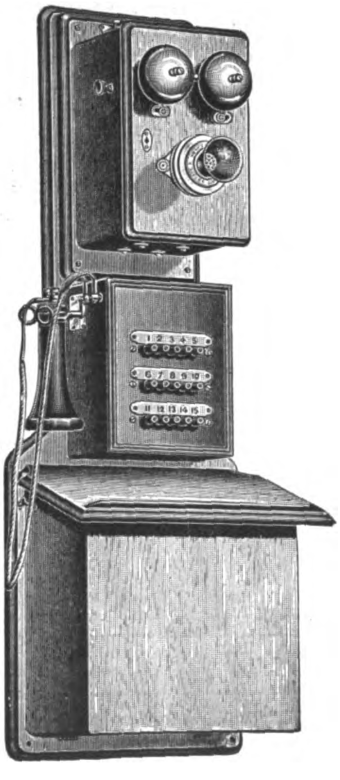

FIG. 5.—WALL TELEPHONE.

The method of signalling and obtaining a connection is the same as has been already described in connection with the local battery method of wiring. The distribution of talking current, however, is rather different, as will be seen by considering the connection between stations *I* and *III*, station *I* being the instrument at which a call is supposed to have originated and station *III* having been signalled. The receivers at both stations having been removed from the hook, current flows from the talking battery through one of the retardation coils to line 1 and over the line to the automatic switch at station *I*, through the transmitter and primary winding of the induction coil, through the hook switch contacts, back over the other side of line 1, and through the retardation coil to the battery. At the same time current is flowing through the retardation coil connected to line 3, over the line and through the transmitter and primary winding of the induction coil at station *III*, through the hook switch contacts at the station and back through the other retardation coil to the battery. Lines 1 and 3 are connected to the automaitc switch at station *I*, and in consequence changes in the current flowing in either line, due to the variation in the resistance of either of the transmitters, produce similar changes in the other line and the other transmitter and repeat the conversation to the closed secondary circuit through the medium of the induction coil.

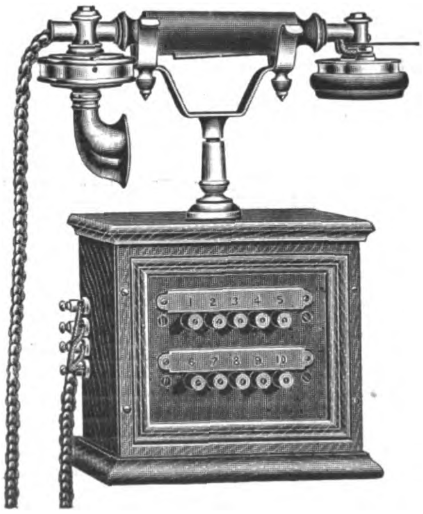

FIG. 6.—DESK TELEPHONE SET.

The retardation or choke coils used with this method of wiring are wound on a soft iron core and each winding has a resistance of about 8 ohms. These coils have, however, a very high impedance to the high-frequency talking currents and thus effectually prevent interference between the various circuits by cross talk. In installing this central battery method of wiring, care must be taken to see that the coils are connected to the proper sides of their respective lines, because, as an inspection of the drawing will show, for proper operation correct polarity must be observed.

In wiring the central battery system for use with a common return for all instruments, a retardation coil is used for one side of each line connected to one terminal of the battery and a single coil connects the other battery terminal to the common return. The use of magneto generators and polarized bells, of course, depends upon the length of the lines, and their installation causes no material change in the wiring.

Fig. 5 shows the application of 15-point automatic switch to the wall type of instrument, and in Fig. 6 is shown a desk set equipped with a 10-point switch and hand microphone, the microphone bracket taking the place of the hook switch and operating the releasing mechanism. The method of wiring to be used in any particular case will depend largely upon the number of stations installed and upon the usage to which they will be subjected. The complete metallic circuit, while it is somewhat more expensive than the common return method of wiring, would probably be found to give sufficiently greater effectiveness in a large installation where the lines are liable to be busy to warrant its additional cost.

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A SIMPLE PRONY BRAKE.

In the course of an interesting paper relating to a method of testing gas engines, read recently before the American Society of Mechanical Engineers, Mr. E. C. Oliver described a very simple and substantial form of Prony brake; his description and illustration are reprinted herewith, and will doubtless be found of value to those whose work includes making brake measurements.

The brake wheel is of cast iron, 24 ins. in diameter and 4½ ins. wide on the face, and is arranged for water cooling, the rim of the wheel being flanged internally in order to retain the cooling water. The brake shoes are of poplar backed by 1-in. maple pieces as indicated in the illustration, and the poplar strips are assembled askew, as shown by the plan view in the illustration. Those strips which provide the friction load are ½ in. thick and are separated by ¼-in. strips which are cut to a larger radius on the curved edge so that they cannot come in contact with the brake wheel.

The ¼-in. channels thus left between the ½-in. poplar strips afford space for lubricating material. The brake arm consists of two pieces of ¾-in. wrought iron pipe flattened at one end and riveted together at that end; the method of securing the other ends is plainly shown in the engraving.

The lower brake shoe is connected rigidly to the upright piece of pipe to which the brake arm is secured, and the connection between the floor flange on the extension of the pole shoe and the tee to which the upper member of the brake arm is screwed has a right and left nipple fitted loosely in both the floor flange and the tee so that it may be readily adjusted. A bolt through the flanges, nipples and pipe holds the two shoes rigidly together after adjustment has been made. Adjustment of the friction load is made at the opposite side of the brake by means of the rod and hand wheel shown in the engraving, and the counter weight is attached to a tee opposite the center of the pulley. Mr. Oliver states in his paper that this brake maintains a steady and uniform load in operation with very little attention and is capable of absorbing much more power than that for which it was designed, namely, 10 horse-power at 300 r.p.m.

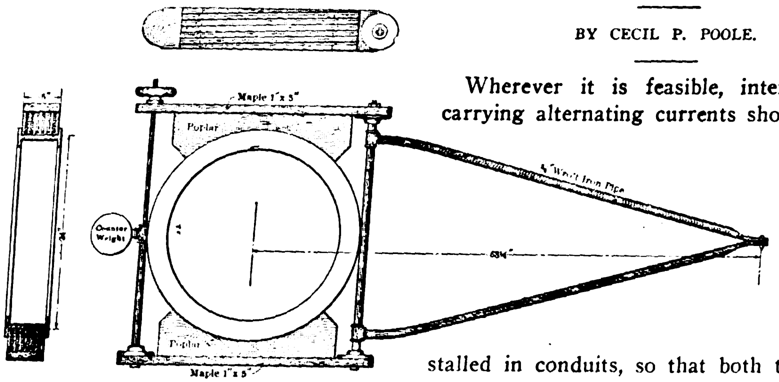

FIG. I.—PRONY BRAKE.

TABLE I.

Power Factors and Inductance Factors.

Power Factor p	Inductance Factor q	Power Factor p	Inductance Factor q
.70	.7142	.85	.5267
.71	.7042	.86	.5103
.72	.6940	.87	.4930
.73	.6835	.88	.4750
.74	.6726	.89	.4560
.75	.6614	.90	.4360
.76	.6500	.91	.4147
.77	.6380	.92	.3920
.78	.6258	.93	.3675
.79	.6131	.94	.3410
.80	.6000	.95	.3123
.81	.5864	.96	.2800
.82	.5724	.97	.2430
.83	.5578	.98	.1990
.84	.5426	.99	.1410

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ALTERNATING CURRENT WIRING.

BY CECIL P. POOLE.

Wherever it is feasible, interior wires carrying alternating currents should be installed in conduits, so that both the wires of a single-phase circuit and all those of a polyphase circuit may be put just as close to each other as the insulation will allow, and the reactive effect of the circuit thus reduced to a negligible quantity. When wires feeding incandescent lamps are so arranged, the drop and carrying capacity may be calculated exactly as in the case of direct-current wiring, the drop being given by the formula:

$$V = \frac{22 L I}{d^2} \qquad (1)$$

or the size of wire by the formula:

$$d^2 = \frac{22 \times L \times I}{V} \qquad (2)$$

in which

I = Amperes per wire;
L = Length of circuit in feet (length of one wire);
d^2 = Circular mils of wire cross-section;
V = Drop in volts.

If one wishes to work in percentages,

$$D = \frac{2200 L I}{E d^2} \qquad (3)$$

$$d^2 = \frac{2200 L I}{E D} \qquad (4)$$

in which E represents the e.m.f. at the load, and D, the drop in percentage of that e.m.f. Thus if the distance were 56 feet, the current 37 amperes, the size of wire 10,380 circular mils (No. 10 B. & S. gauge), the drop, V, would be practically 4.4 volts, and if the e.m.f. at the lamps were 110 volts, the drop in percentage (D) would be 2 per cent.

It is common custom to take 21 or 21.5 as the constant in formulas (1) and (2), and 2,100 or 2,150 in formulas (3) and (4), for the reason that the resistance per mil-foot of copper wire at about 70° Fahr. is 10.5 to 10.8 ohms; the slightly larger value of 22 is used here in order to make a little allowance for the discrepancy between the actual length and the calculated length of a stretch of wire. The difference is not of serious importance, however, since no one ever calculates wiring to such a fine degree of accuracy as to make it necessary to measure the length to an inch.

When the load is an inductive one, such as arc lamps and motors, it is necessary to know, at least approximately, what the power factor is going to be in order to predetermine with some approach to accuracy the drop in a given wire for a given load and distance. The formula for such cases is rather a formidable one, *viz.*—

$$D = 100 \times \sqrt{\left(p + \frac{I R}{E}\right)^2 + q^2} - 100 \qquad (5)$$

for a single-phase circuit, one-half of a two-phase circuit, or a three-wire, three-phase circuit. In this formula, p represents the power factor and q the inductance factor of the load. The power factor may be ascertained from the manufacturer of the apparatus, and when this is known, the inductance factor may be taken from Table I herewith. The symbol, R, in the formula

TABLE II.—Resistance of Copper Wires.

Calculated for parallel wires each 1000 feet long, at 75° Fahrenheit.

Wire numbers; B. & S. Gauge.	Actual resistance of two wires of a single-phase circuit.	Effective resistance of three wires of a three-phase circuit.
00	.158	.1374
0	.199	.1731
1	.252	.2191
2	.316	.2747
3	.401	.3487
4	.505	.4392
5	.635	.5522
6	.801	.6966
8	1.283	1.116
10	2.023	1.759
12	3.2	2.782

TABLE III.—Reactance of Copper Wires. Calculated for Parallel Wires each 1000 Feet Long.

Note:—The values in the body of the table are actual reactances for the two wires of a single-phase circuit and effective reactances for the three wires of a three-phase circuit.

Wire numbers; B. & S. gauge.	Reactance at 60 cycles.										Reactance at 133 cycles.									
	3" apart.		6" apart.		9" apart.		12" apart.		18" apart.		3" apart.		6" apart.		9" apart.		12" apart.		18" apart.	
	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase	Single-phase.	Three-phase.	Single-phase.	Three-phase.	Single-phase.	Three-phase.
00	.1402	.1219	.1720	.1495	.1907	.1658	.2039	.1773	.2226	.1936	.3116	.2710	.3824	.3325	.4238	.3685	.4532	.3941	.4946	.4301
0	.1456	.1266	.1774	.1543	.1960	.1704	.2093	.1820	.2279	.1975	.3234	.2812	.3942	.3428	.4356	.3788	.4650	.4043	.5064	.4403
1	.1510	.1313	.1827	.1589	.2014	.1751	.2146	.1866	.2332	.2028	.3353	.2916	.4060	.3530	.4475	.3891	.4768	.4145	.5183	.4507
2	.1563	.1359	.1880	.1635	.2067	.1797	.2199	.1912	.2386	.2075	.3471	.3018	.4179	.3634	.4593	.3994	.4887	.4249	.5300	.4608
3	1616	.1405	.1934	.1682	.2120	.1843	.2253	.1959	.2439	.2121	.3589	.3121	.4297	.3736	.4712	.4097	.5005	.4352	.5420	.4713
4	.1670	.1452	.1987	.1728	.2174	.1891	.2306	.2005	.2492	.2167	.3708	.3224	.4416	.3840	.4830	.4200	.5124	.4455	.5538	.4816
5	.1723	.1498	.2040	.1774	.2227	.1974	.2359	.2051	.2546	.2214	.3826	.3327	.4534	.3942	.4948	.4303	.5242	.4558	.5656	.4883
6	.1776	.1544	2094	.1821	.2280	.1983	.2413	.2098	.2599	.2260	.3945	.3431	.4653	.4046	.5067	.4406	.5361	.4662	.5775	.5021
8	.1883	.1637	.2200	.1913	.2387	.2076	.2519	.2190	.2706	.2353	.4182	.3637	.4889	.4251	.5304	.4612	.5598	.4868	.6012	.5228
10	.1989	.1729	.2307	.2006	.2493	.2168	.2626	.2284	.2812	.2445	.4418	.3842	.5127	.4458	.5540	.4793	.5834	.5073	.6249	.5434
12	2095	.1822	.2414	.2099	.2600	.2261	.2732	.2376	.2919	.2538	.4655	.4048	.5363	.4663	.5777	.5023	.6071	.5279	.6485	.5639

represents the actual resistance of the two wires of a single-phase circuit or half of a two-phase circuit, and the "effective" resistance of a three-phase circuit. Table II gives the resistance per 1,000 feet of line for single-phase circuits, and the corresponding values of R to use in calculating three-phase circuits. In order to ascertain the resistance of a single-phase line, or the "effective" resistance of a three-phase line, it is only necessary to multiply the proper number in the table by the length of the line and divide the result by 1,000. It must be remembered, however, that the length of a line or circuit, in this sort of work, is always the length of *one* wire of the circuit, no matter how many wires there may be.

When the wires are not run in conduits, but on cleats or knobs, the calculation for drop is complicated somewhat more by the self-induction of the line wires, which increases the drop, but not directly. The formula for drop in separated wires supplying a non-inductive load, such as incandescent or Nernst lamps, is

$$D = 100\sqrt{\left(1 + \frac{IR}{E}\right)^2 + \left(\frac{IX}{E}\right)^2} - 100 \quad (6)$$

and when the load is inductive and the wires are separated,

$$D = 100\sqrt{\left(p + \frac{IR}{E}\right)^2 + \left(q + \frac{IX}{E}\right)^2} - 100 \quad (7)$$

In these last formulas a new quantity has been introduced, namely, the reactance of the circuit wires, represented by the letter X. The value of this varies with the fre-

TABLE IV.—For Low-Potential Single-Phase or Two-Phase Circuits.

Note:—The values in the body of the table are Ampere-Feet; *i. e.*, amperes per wire × length of one wire.

Energy drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$			Wire Numbers; B. & S. Gauge.								
400 V.	200 V.	100 V.	1	2	3	4	5	6	8	10	12
		1 %	3,968	3,164	2,494	1,980	1,575	1,248	773	494	312
		1¼	4,961	3,952	3,117	2,475	1,968	1,566	966	618	390
		1½	5,952	4,747	3,740	2,970	2,362	1,872	1,159	742	468
		1¾	6,944	5,538	4,364	3,466	2,756	2,184	1,352	865	546
	1 %	2	7,937	6,329	4,988	3,961	3,150	2,496	1,546	989	624
	1¼	2½	9,921	7,906	6,234	4,950	3,937	3,121	1,932	1,236	780
	1½	3	11,904	9,484	7,481	5,941	4,724	3,744	2,319	1,483	936
	1¾	3½	13,888	11,075	8,728	6,931	5,512	4,368	2,705	1,730	1,092
1 %	2	4	15,873	12,658	9,975	7,921	6,299	4,992	3,092	1,977	1,248
1¼	2½	5	19,842	15,820	12,468	9,901	7,874	6,242	3,864	2,472	1,560
1½	3	6	23,808	18,978	14,962	11,882	9,449	7,488	4,638	2,966	1,872
1¾	3½	7	27,777	22,150	17,455	13,862	11,024	8,736	5,410	3,460	2,184
2	4	8	31,745	25,315	19,950	15,842	12,598	9,984	6,184	3,955	2,496
2½	5	10	39,683	31,643	24,937	19,802	15,748	12,484	7,728	4,943	3,125
3	6	12	47,618	37,956	29,925	23,763	18,898	14,976	9,276	5,932	3,744

TABLE IVa.—For Low-Potential Three-Phase Circuits.

Note:—The values in the body of the table are Ampere-Feet; *i. e.*, current per wire × length of one wire.

Energy drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$			Wire Numbers; B. & S. Gauge:								
400 V.	200 V.	100 V.	1	2	3	4	5	6	8	10	12
		1 %	4,564	3,639	2,868	2,278	1,812	1,436	889	568	360
		1¼	5,704	4,548	3,585	2,847	2,264	1,795	1,111	711	449
		1½	6,845	5,458	4,302	3,417	2,717	2,154	1,334	853	540
		1¾	7,989	6,369	5,019	3,986	3,170	2,513	1,556	995	630
	1 %	2	9,127	7,278	5,736	4,555	3,623	2,872	1,778	1,137	720
	1¼	2½	11,409	9,096	7,170	5,694	4,529	3,589	2,223	1,421	899
	1½	3	13,690	10,917	8,604	6,833	5,434	4,308	2,667	1,706	1,080
	1¾	3½	15,978	12,738	10,038	7,972	6,340	5,026	3,112	1,939	1,260
1 %	2	4	18,253	14,556	11,472	9,110	7,245	5,744	3,556	2,274	1,440
1¼	2½	5	22,819	18,192	14,340	11,388	9,057	7,179	4,445	2,842	1,798
1½	3	6	27,380	21,834	17,208	13,665	10,868	8,616	5,334	3,411	2,160
1¾	3½	7	31,945	25,475	20,076	16,943	12,680	10,052	6,223	3,979	2,520
2	4	8	36,506	29,112	22,944	18,220	14,490	11,488	7,112	4,547	2,880
2½	5	10	45,638	36,390	28,680	22,775	18,114	14,358	8,890	5,684	3,595
3	5	12	54,760	43,668	34,416	27,330	21,736	17,232	10,668	6,820	4,320

TABLE V.—For Single-Phase or Two-Phase Primary Lines.

Note:—The values in the body of the table are Ampere-Feet; *i. e.*, current per wire × length of one wire.

Energy drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$			Wire Numbers; B. & S. Gauge:									
6000 V.	2000 V.	1000 V.	00	0	1	2	3	4	5	6	8	10
		2%	126,580	100,510	79,365	63,288	49,880	39,610	31,500	24,960	15,460	9,866
	2 %	4	253,160	201,020	158,730	126,576	99,750	79,210	62,990	49,920	30,920	19,772
	2½	5	316,470	251,260	198,420	158,220	124,680	99,010	78,740	62,420	38,640	24,715
1%	3	6	379,760	301,510	238,080	189,864	149,620	118,820	94,490	74,880	46,380	29,658
	3½	7	443,040	351,760	277,777	221,500	174,550	138,620	110,240	87,360	54,100	34,602
	4	8	506,320	402,200	317,450	253,152	199,500	158,420	125,980	99,840	61,840	39,545
	5	10	632,940	502,520	396,825	316,440	249,370	198,020	157,480	124,840	77,275	49,430
2	6	12	759,520	603,020	476,180	379,738	299,250	237,630	188,980	149,760	92,760	59,315
	7	14	886,100	703,520	555,560	443,000	349,120	277,220	220,470	174,720	108,200	69,210
	8	16	1,012,700	804,400	634,900	506,304	399,000	316,830	251,980	199,680	123,680	79,090
5	10	20	1,265,800	1.005,100	793,650	632,880	498,800	396,100	315,495	249,600	154,550	98,860
6	12		1,519,000	1,206,200	952,400	759,476	598,500	475,250	377,950	299,520	185,520	118,640
7	14		1,772,200	1,407,000	1,111,110	886,000	698,250	554,500	440,950	349,440	216,400	138,410
8	16		2,025,300	1,608,000	1,269,800	1,012,608	798,000	633,700	503,900	399,360	247,360	158,180
10	20		2,531,600	2,010,200	1,587,200	1,265,760	997,500	792,100	629,900	499,200	309,100	247,150

TABLE Va.—For Three-Phase Primary Lines.

Note:—The values in the body of the table are Ampere-Feet; *i. e.*, current per wire × length of one wire.

Energy drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$			Wire Numbers; B. & S. Gauge:									
6000 V.	2000 V.	1000 V.	00	0	1	2	3	4	5	6	8	10
		2%	145,560	115,590	91,270	72,720	57,360	45,550	36,230	28,720	17,780	11,370
	2 %	4	291,120	231,700	182,530	145,440	114,720	91,100	72,450	57,440	35,560	22,740
	2½	5	363,950	288,950	228,190	181,790	143,400	113,880	90,570	71,790	44,450	28,420
1%	3	6	436,700	346,750	273,800	218,160	172,080	136,650	108,680	86,160	53,340	34,100
	3½	7	509,500	404,520	319,450	254,550	200,760	159,430	126,800	100,520	62,230	39,790
	4	8	582,200	462,500	365,060	290,880	229,440	182,200	144,900	114,880	71,120	45,470
	5	10	727,800	577,850	456,380	363,580	286,800	227,750	181,141	143,580	88,900	56,840
2	6	12	873,400	693,500	547,600	436,320	344,160	273,300	217,360	172,320	106,680	68,200
	7	14	1,019,000	809,040	638,900	509,100	401,520	318,850	253,590	201,040	124,460	79,580
	8	16	1,164,500	925,000	730,120	581,760	458,880	364,400	289,800	229,760	142,240	90,940
5	10	20	1,455,600	1,155,900	912,650	727,160	573,600	455,500	362,270	287,200	177,800	113,680
6	12		1,746,800	1,387,000	1,095,200	872,640	688,320	546,600	434,720	344,640	213,360	136,400
7	14		2,038,000	1,618,080	1,277,800	1,018,200	802,040	637,700	507,180	402,080	248,920	159,160
8	16		2,329,100	1,850,000	1,460,240	1,163,520	917,760	736,800	579,600	459,420	284,480	181,880
10	20		2,911,200	2,3[illegible],400	1,825,300	1,454,320	1,147,200	911,000	724,540	574,400	355,600	227,400

quency of the alternating current and with the distance apart of the wires. Table III gives the reactance per 1,000 feet of two parallel wires various distances apart, for the standard sizes, and also the "effective" reactance of the three wires of a three-phase line. As in the case of the resistances, the "effective" values must be used in formulas (6) and (7) when calculating the drop in three-phase circuits.

In order to further facilitate the use of these formulas, Tables IV, IV-a, V, V-a, VI and VII have been prepared, from which the values of $\frac{IR}{E}$ and $\frac{IX}{E}$ for single-phase, two-phase and three-phase circuits may be taken without calculation beyond merely multiplying the current per wire by the distance in feet in order to obtain the "ampere-feet" of the circuit. Having this, find the nearest value in the body of the proper table, in the column under the desired size of wire, and the energy or resistance loss for this size will be found at the left-hand end of the line in which the number of ampere-feet is located. Conversely, the size of wire that will be required for a given energy loss may be determined by tracing from that energy drop into the table to the right, until the nearest value of ampere-feet is found; at the head of the column in which this is located will be the size of wire to be used.

Having found the value of $\frac{IR}{E}$ by means of one of the tables IV to V-a, the corresponding value of $\frac{IX}{E}$ for a line having separated wires may be taken directly from the proper reactance drop table—VI for indoor wires, or VII for out-door wires.

It has been found by Mr. N. R. Craighill, however, that the relation between the energy drop and the actual drop, with a given power factor and line inductance, is so nearly a straight-line function that it may be considered so with less error than

TABLE VIII.—Values of *A* and *B* with Wires 3 inches apart and a Frequency of 60 Cycles.

Power factor; per cent.	Wire Numbers; B. & S. Gauge: 1		2		3		4		5		6		8		10	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
100	.007	.993	.005	.995	.004	.996	.004	.997	.003	.998	.001	.999	.000	1.000	.000	1.000
98	.024	.902	.015	.921	.015	.936	.014	.951	.020	.961	.015	.973	.010	.989	.000	1.000
96	.033	.876	.007	.908	.004	.930	.003	.945	.010	.962	.007	.976	.000 +	1.000	.006 +	1.012
94	.001	.873	.008 +	.900	.005	.925	.001 +	.949	.010 +	.962	.002 +	.985	.002 +	1.011	.005. +	1.028
92	.000 +	.866	.001 +	.899	.005	.924	.001 +	.951	.001	.973	.026	1.008	.017	1.022	.005 +	1.043
89	.001	.859	.001	.902	.003	.927	.001	.959	.000 +	.985	.000	1.007	.000	1.043	.003 +	1.068
86	.000 +	.858	.000 +	.899	.010	.934	.002	.969	.009	1.006	.002	1.026	.003	1.066	.002 +	1.097
83	.002	.861	.001	.905	.028	.936	.000	.983	.000	1.016	.001	1.047	.032	1.080	.002	1.127
80	.000	.862	.000	.962	.004	.956	.002	.999	.006	1.030	.040	1.043	.000	1.125	.000	1.160

TABLE VI.—Values of $\frac{IX}{E}$ for Wires 3 inches Apart.

Energy Drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$	60 Cycles Frequency. Wire Numbers; B. & S. Gauge: 1	2	3	4	5	6	8	10	133 Cycles Frequency. Wire Numbers; B. & S. Gauge: 1	2	3	4	5	6	8	10	12
1¼%	.0065	.0062	.0051	.0042	.0034	.0028	.0019	.0012	.0167	.0137	.0113	.0092	.0075	.0062	.0041	.0027	.0018
1½	.0090	.0074	.0060	.0050	.0041	.0033	.0022	.0015	.0200	.0165	.0135	.0110	.0091	.0074	.0049	.0033	.0022
1¾	.0105	.0087	.0071	.0058	.0048	.0039	.0026	.0017	.0234	.0192	.0158	.0129	.0105	.0086	.0058	.0038	.0025
2	.0120	.0099	.0081	.0066	.0054	.0044	.0030	.0020	.0260	.0220	.0180	.0147	.0121	.0099	.0066	.0044	.0029
2½	.0150	.0124	.0101	.0083	.0068	.0055	.0037	.0025	.0334	.0275	.0225	.0184	.0151	.0123	.0082	.0055	.0036
3	.0180	.0148	.0122	.0100	.0082	.0066	.0044	.0029	.0401	.0329	.0270	.0221	.0181	.0148	.0099	.0066	.0044

TABLE VII.—Values of $\frac{IX}{E}$ for Wires 12 inches Apart.

Energy Drop in per cent of E. $\left(\frac{IR}{E}\times 100\right)$	60 Cycles Frequency. Wire Numbers; B. & S. Gauge: 00	0	1	2	3	4	5	6	8	133 Cycles Frequency. Wire Numbers; B. & S. Gauge: 00	0	1	2	3	4	5	6	8	10
2%	.0259	.0210	.0171	.0139	.0113	.0091	.0075	.0060	.0040	.0574	.0467	.0380	.0309	.0251	.0238	.0165	.0134	.0088	.0058
5	.0646	.0526	.0428	.0348	.0283	.0229	.0186	.0151	.0099	.1435	.1167	.0950	.0772	.0627	.0595	.0413	.0335	.0220	.0145
6	.0775	.0631	.0513	.0417	.0339	.0275	.0223	.0181	.0119	.1722	.1400	.1140	.0926	.0752	.0714	.0496	.0402	.0264	.0173
7	.0903	.0736	.0598	.0487	.0396	.0321	.0260	.0211	.0139	.2010	.1635	.1330	.1080	.0878	.0833	.0578	.0469	.0308	.0202
8	.1032	.0841	.0684	.0553	.0452	.0366	.0297	.0242	.0158	.2295	.1870	.1520	.1235	.1002	.0952	.0661	.0536	.0352	.0231
10	.1290	.1050	.0855	.0695	.0565	.0458	.0372	.0302	.0198	.2870	.2335	.1900	.1544	.1254	.1190	.0826	.0670	.0440	.0289
12½	.1615	.1314	.1068	.0869	.0706	.0573	.0466	.0377	.0248	.3590	.2920	.2375	.1930	.1567	.1487	.1032	.0838	.0550	.0361

TABLE IX.—Values of *A* and *B* with Wires 3 inches apart and a Frequency of 133 Cycles.

Power factor; per cent.	Wire Numbers; B. & S. Gauge: 1		2		3		4		5		6		8		10		12	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
100	.038	.962	.027	.974	.017	.983	.011	.989	.007	.993	.005	.995	.004	.997	.001 +	.999	.000	1.000
98	.024	.785	.032	.811	.028	.852	.011	.882	.000	.907	.000	.938	.000	.956	.009	.980	.010	.987
96	.008	.740	.008 +	.782	.008	.819	.006	.854	.004	.884	.014	.906	.000	.950	.006 +	.977	.000	1.000
94	.015	.707	.024 +	.771	.003	.799	.004	.837	.002 +	.872	.000 +	.903	.002	.949	.006 +	.992	.002 +	1.008
92	.012	.685	.050	.752	.002	.783	.002	.825	.005 +	.866	.002	.898	.000	.952	.002 +	.994	.002	1.022
89	.008	.663	.000 +	.717	.000	.767	.000	.818	.003 +	.859	.000	.896	.000 +	.962	.002	1.009	.000 +	1.043
86	.008	.644	.002 +	.704	.002	.757	.004	.808	.004 +	.858	.000 +	.899	.003	.976	.002	1.026	007	1.070
83	.007	.632	.002 +	.693	.000	.750	.003	.805	.006	.858	.002	.905	005	.983	.001	1.046	.002	1.092
80	.006	.624	.003	.686	.000	.746	.005	.804	.004	.860	.000	.962	002	.999	.040	1.043	.000	1.125

that involved in calculating the length of a circuit. On this assumption, the actual drop in percentage of the delivered e.m.f. may be computed by means of the very simple formula

$$D = \frac{\frac{IR}{E} - A}{B} \qquad (8)$$

in which A and B are empirical values, different for different values of power factor and line inductance. Tables VIII to XI inclusive give the values of A and B for four combinations of frequency and distance apart of the circuit wires.

TABLE X.—Values of *A* and *B* with Wires 12 inches apart and a Frequency of 60 Cycles.

Power factor; per cent.	Wire Numbers; B. & S. Gauge:																	
	00		0		1		2		3		4		5		6		8	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
100	.135	.918	.090	.944	.064	.962	.045	.974	.030	.982	.017	.989	.014	.992	.008	.995	.000	.999
98	.075	.771	.050	.816	.031	.854	.018	.884	.010	.910	.005	.931	.003	.948	.003	.961	00.	.982
96	.055	.730	.062	.778	.022	.823	.013	.860	.050	.880	.004	.918	.002	.940	.008	.958	.022	.983
94	.045	.104	.026	.758	.018	.805	.007	.846	.004	.882	+.008	.916	+.002	.938	.002	.958	.000	.992
92	.033	.686	.020	.741	.012	.791	.004	.836	.000	.876	+.001	.910	.000	.938	+.001	.963	.000	1.000
89	.025	.665	.015	.724	.010	.778	.009	.827	+.002	.872	.005	.908	+.005	.944	.004	.972	.004	1.016
86	+.058	.675	.026	.706	.005	.770	.002	.823	+.002	.872	.018	.912	+001	.952	.027	.982	.020	1.033
83	.010	.640	.005	.704	.000	.765	.025	.811	+.002	.874	+.020	.930	.000	.962	.010	.996	.015	1.055
80	.008	.632	.003	.698	.002	.762	.000	.822	.003	.878	.010	.928	004	.974	.015	1.012	.015	1.075

TABLE XI.—Values of *A* and *B* with Wires 12 inches Apart and a Frequency of 133 Cycles.

Power factor; per cent.	Wire Numbers; B. & S. Gauge:																			
	00		0		1		2		3		4		5		6		8		10	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
100	.480	.695	.370	.775	.267	.838	.187	.886	.128	.922	.125	.929	.045	.974	.038	.977	.017	.990	.005	.996
98	.280	.527	.270	.599	.256	.666	.108	.726	.072	.778	.065	.789	.032	.857	.015	.890	.005	.934	.004	.962
96	.240	.483	.180	.552	.125	.619	.090	.679	.060	.738	.050	.750	.022	.830	.020	.867	.005	.922	.004	.950
94	.202	.456	.120	.526	.105	.590	.066	.654	.042	.712	.040	.726	.015	.812	.020	.852	.001	.918	.000	.962
92	.170	.436	.235	.473	.087	.568	.056	.633	.035	.694	.010	.722	.007	.800	.004	.844	.002	.917	+.001	.967
89	.155	.414	.100	.480	.070	.546	.045	.611	.028	.674	.025	.689	.010	.787	.004	.836	+.002	.916	.000	.977
86	.120	.398	.085	.463	.084	.528	.010	.592	.020	.660	.015	.675	.006	.778	.005	.832	.002	.922	.002	.990
83	.100	.386	.068	.449	.045	.515	.025	.582	.014	.649	.007	.666	.012	.774	.050	.832	.040	.928	.050	1.003
80	.085	.376	.055	.439	.035	.504	.020	.572	.008	.641	.007	.658	.002	.772	.000	.832	003	.938	.112	1.020

This formula gives results that seldom exceed 2 per cent error in the percentage drop, which, of course, is negligible, since it is a percentage of a percentage. In a few cases, the value of A is negative, so that it must be added to $\frac{IR}{E}$ instead of subtracted from it. These values are identified in the tables by the + sign, indicating that they must be added to $\frac{IR}{E}$ in the formula. This formula is not only very much easier of solution than any of the orthodox equations, (5) to (7), but it has the advantage of being solvable for either the actual drop or the energy drop, which is not true of the others. For ascertaining the energy drop corresponding to a given actual drop, it would be transposed, of course, to read

$$\frac{IR}{E} = DB + A \qquad (9)$$

In using this last formula, the values of A marked + in the tables must be ***subtracted*** from $D \times B$.

Table XII has been added for the benefit of those who may have occasion to compute the drop in wires at some distance apart other than 3 or 12 inches. This gives the ratio of reactance to resistance, and applies to circuits having any number of phases, provided the wires are arranged symmetrically so as to balance up the mutual inductance. By means of this table the value of $\frac{IX}{E}$ may be obtained for any practical conditions involving either of the standard frequencies. Having ascertained the value of $\frac{IR}{E}$, it is only necessary to multiply it by the number in Table XII that corresponds to the wire, frequency and distance apart, in order to obtain $\frac{IX}{E}$. All of the values are then at hand for solving either formula (6) or (7).

TABLE XII.—Values of $\frac{X}{R}$ at 75° Fahrenheit for Various Distances apart of Circuit Wires.

Wire numbers; B. & S. Gauge.	60 Cycles Frequency.							133 Cycles Frequency.						
	3"	4"	6"	9"	12"	18"	24"	3"	4"	6"	9"	12"	18"	24"
0000	1.309	1.440	1.630	1.815	1.948	2.136	2.270	2.908	3.198	3.616	4.040	4.340	4.758	5.050
000	1.079	1.183	1.332	1.480	1.586	1.735	1.840	2.394	2.628	2.959	3.290	3.530	3.860	4.090
00	.888	.972	1.090	1.208	1.292	1.410	1.494	1.972	2.159	2.422	2.685	2.872	3.134	3.320
0	.732	.798	.892	.985	1.051	1.145	1.212	1.625	1.773	1.981	2.189	2.337	2.545	2.692
1	.598	.560	.725	.799	.852	.926	.977	1.332	1.444	1.612	1.776	1.892	2.056	2.172
2	.495	.537	.596	.655	.697	.756	.797	1.101	1.194	1.324	1.455	1.549	1.680	1.783
3	.403	.436	.482	.529	.562	.608	.641	.895	.968	1.072	1.175	1.250	1.352	1.425
4	.332	.358	.395	.432	.458	.495	.522	.734	.795	.874	.956	1.019	1.096	1.159
5	.272	.292	.322	.351	.372	.401	.422	.603	.649	.715	.780	.826	.890	.938
6	.221	.238	.261	.285	.301	.325	.341	.492	.531	.580	.632	.669	.718	.758
7	.181	.194	.213	.231	.244	.263	.276	.403	.432	.473	.514	.543	.584	.613
8	.145	.155	.170	.184	.194	.209	.219	.323	.346	.378	.410	.432	.465	.487
9	.120	.128	.139	.151	.159	.171	.179	.266	.284	.310	.337	.354	.379	.397
10	.098	.105	.114	.123	.130	.139	.145	.219	.233	.254	.274	.289	.309	.324
12	.065	.069	.075	.081	.085	.091	.095	.145	.154	.168	.181	.190	.203	.212
14	.043	.046	.049	.053	.055	.059	.062	.096	.102	.110	.118	.123	.132	.137

THE HOT-WELL AS AN OIL EXTRACTOR.

BY A. H. ELDREDGE.

Figs. 1 and 2 give the plan and cross-section of a hot-well that has been in successful operation during the past year. The well is divided into three parts; *A*, the common discharge side for the steam condensers; *B*, the discharge side for one steam condenser, and *C*, the hot side, or pump side. The operation of the well is as follows: The bulk of the condensing water enters at *A* and overflows to a cistern at *D*. The water from a single jet condenser enters *B*. The water from this condenser comes from an engine that runs continuously nearly the entire year. Its temperature is kept between 125° and 160° Fahr. to favor the boiler feed temperatures, although at the expense of the vacuum, which runs from 20 inches to 24 inches. The higher temperature also saves condensing water.

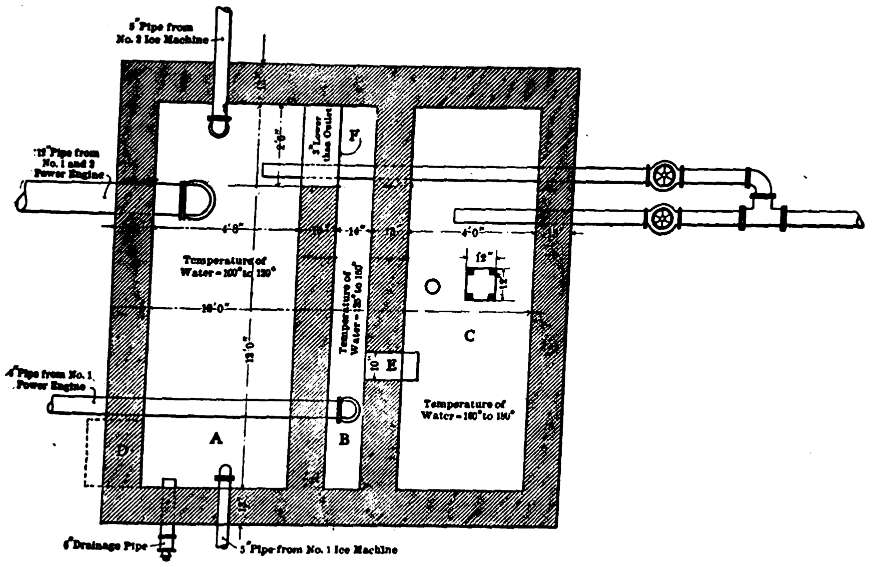
5" Pipe from No. 2 Ice Machine
12" Pipe from No. 1 and 2 Power Engine
4" Pipe from No. 1 Power Engine
6" Drainage Pipe
5" Pipe from No. 1 Ice Machine
2'0"
3" Lower than Outlet
F
4'0"
16"
13
4'0"
12"
12"
Temperature of Water = 100° to 120°
Temperature of Water = 125° to 160°
Temperature of Water = 160° to 180°
16'0"
13'0"
10"
E
C
A
B
D

FIG. I.—PLAN VIEW SHOWING CONNECTIONS TO HOT-WELL.

There are two outlets from *B*, one an underflow at *E* into *C*, and one an overflow at *F* into *A*. The overflow at *F* is 3 inches lower than the one at *D* to insure a free passage in and out of *B*.

The hot side, or pump suction side, *C*, is supplied from *B* through *E*. The temperature of this water is increased by returning to it, so far as possible, all steam drips, and pump, or other exhausts, raising its temperature to from 160° to 180° Fahr. This gives a good start for a desirable feed-water temperature and at the same time saves many traps, together with their accompanying troubles and expense, insuring the return of the various drips, with their heat units, to the boilers.

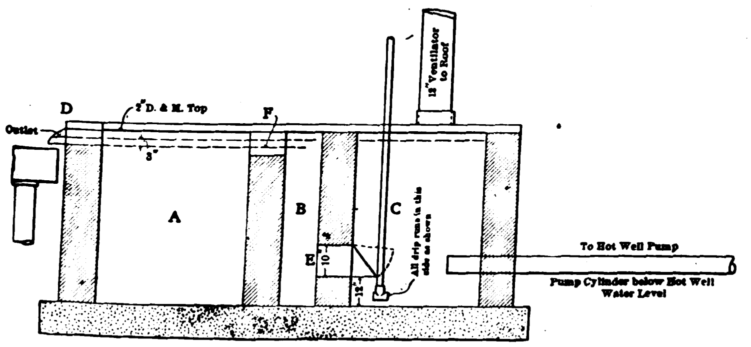
D
2" D. & M. Top
F
Outlet
3"
12" Ventilator to Roof
A
B
C
E
10
12
All drip runs in this side as shown
To Hot Well Pump
Pump Cylinder below Hot Well Water Level

FIG. 2.—CROSS-SECTIONAL VIEW OF HOT-WELL.

The only outlet from *C* is through the pump suction, and only such water enters *C* as is sufficient to supply the pump. Should the water at any time be cut off from *B*, then the supply would come automatically from *A* through *F*. The hot-well is provided with drain pipes in *A* and *C* for clean-out purposes.

The water enters *B* at a comparatively high temperature, and any oil in the water will rise rapidly to the surface, while the oil from but one condenser is all that has to be taken care of. At the same time the flow of the water from *B* to *C* is very slow, giving ample time for the oil to rise to the surface and pass off through the overflow *F*.

Over 3,000 horse-power of boilers, at one of Swift & Company's plants, is fed from this hot-well, and no sign of oil has been found in any of the boilers or their connections. The water from *C* has also been chemically analyzed a number of times, and only the slightest trace of oil has ever been found. The trace found was undoubtedly due to the oil coming in through a pump exhaust, and has in no way affected the practical working of the hot-well.

[The foregoing is a paper read at the Saratoga meeting of the American Society of Mechanical Engineers.]

THE BOILER BLOW-OFF.

BY W. T. EDWARDS.

The blow-off, being situated somewhat out of sight at the back of the boiler, is apt to have little attention paid to it or to be thought not very important. As a great many serious accidents may be traced directly to defective blow-offs, too much care cannot be taken to protect them from injury. One of the causes most apt to occur is the corrosion of the pipe by the hot gases; strains due to the expansion and contraction resulting from the changes of temperature when the fire door is opened also constitute a frequent cause of trouble; still another cause is the opening and closing of the blow-cock. This would seem to be one of the simplest duties about the care of a boiler, but there is a right and a wrong way to do both.

To get the full benefit of the capacity of the blow-off pipe the cock should be opened to full opening. Pieces of scale may have lodged in the pipe that will require the full area of the cock in order to pass out into the sewer. Now, if the cock is only part way open these pieces of scale stick and in turn cause other and smaller pieces to stop until a dam is formed, clogging the pipe to such a point as to endanger it from burning. It is evident, therefore, that it is important to have the blow-cock fully opened so that the water may have the best chance to clear out anything that may be in the pipe.

In closing the cock one should remember that no valve under pressure should ever be closed suddenly; large valves are equipped with mechanisms to prevent this being done. A large percentage of accidents from the bursting of pipes is due to suddenly closing a valve, against a high pressure, when the blow-off cock has been open for some time, the stream will be flowing through at a high velocity; the momentum of such a stream is very great and a sudden stopping of this momentum is bound to produce a severe shock on the side of the valve and the pipe next the boiler. This shock may be great enough to break an elbow, burst the pipe or even tear the pipe loose from the boiler, and as a result somebody may be badly scalded and a boiler laid off for repairs.

The proper way is to open the blow-off cock slowly to full opening, leave it so as long as is considered necessary, then close it very slowly, taking a relatively long time in the operation.

Engineers use a great deal of ingenuity in trying to protect the blow-off pipe from injury or to place it out of reach of the fire. One case comes to mind of an engineer who had the pipe enter the boiler through the lowest part of the front head, from which point it extended to the rear, where it rested on the bottom of the boiler; the advantage claimed for this method is that the pipe is protected from the fire. The disadvantages are that the pipe is in the way of the boiler washer, and is in the place where the most work has to be done. I believe the engineer had his pipe connected with a coupling just inside the boiler, which permitted the removal of the internal length of pipe when the boiler was to be washed, but he did not say how he removed the two or three inches of water and sediment that remained in the bottom after washing down. I think he claimed that the water left in the bottom would syphon out; this might be true to a certain degree, but when the pipe has been removed to give freedom in washing, one cannot put it back and expect the water to syphon out. Again, assuming that the water is syphoning out, when the level falls to a point below the top wall of the pipe, air gets in and the syphon is lost.

The best practice, in the opinion of the writer, is to have the boiler set with the back about 2 inches lower than the front, in order to allow the mud, sediment and loose scale to settle as near to the blow-off as possible, and to connect the blow-off pipe directly to the bottom of the boiler about 10 inches from the back head, in order to have the connection clear the joint of the head nicely.

The pipe should not be less than 2½ inches in diameter for medium-sized boilers, and the hole in the bottom should be reinforced by a flange riveted onto the plate. After leaving the boiler the pipe should be carried down to the bottom of the heat chamber, then out through the rear wall and on into the sewer. This allows the vertical part of the pipe, which is exposed to the direct action of the gases, to be cheaply protected by being enclosed with fire brick or tile. Another way is to carry the pipe vertically downward about 6 or 8 inches, then directly out through the rear wall, but this is not as good as the first-mentioned way, as the pipe is not so easily protected.

There are several sectional coverings on the market that are very good for protecting blow-off pipes. These usually consist of a sleeve divided lengthwise and having ribs projecting inwardly that keep the covering concentric about the pipe and leave an air space around the blow-off pipe. However, the covering should be carried through the rear wall to get the full benefit. I might add here that a hand hole in the rear head, located conveniently near the blow-off pipe is very desirable, since it makes it very easy to remove the larger pieces of scale by hand.

Another way that is sometimes used to prolong the life of the blow-off pipe is to put in a system of circulating piping made up of much smaller pipe than the blow-off, connected at one end to the blow-off pipe between the cock and the boiler and with the other end entering the back head just below the water line; by means of this arrangement a solid body of water will circulate all the time. This pipe should be provided with a valve close to the blow-off pipe; and the blow-off pipe should have a valve between the boiler and where the small pipe makes connections, so that the small pipe may be used as a surface blow-off.

When trouble is experienced from leaks, it is a good plan to place two plug cocks in the blow-off pipe. Just here the writer wishes to warn against the use, under any circumstances, of a globe valve; trouble will inevitably result if one is used.

As there is always a possibility of accidents happening even in the most carefully regulated power plants, and as a burst blow-off may be one of these it might be well to know just what to do in that case; should the blow-off pipe burst, the first thing to do is to close the valve connecting the boiler to the steam main. This should be done as quickly as possible. Then, if the break is outside of the setting, the fire may be drawn, but if the break is inside, this will hardly be necessary, since the escaping steam and water will quickly extinguish it. One can next turn his attention to shutting off the feed water; but no serious consequences will be entailed if the water is allowed to flow until the boiler has emptied itself, provided, of course, the fire has been drawn, in case the escaping steam and water does not extinguish it.

Lessons in Practical Electricity

SAFETY DEVICES.

As explained in previous Lessons, the passage of current through any conductor will cause a rise of temperature in the conductor. The extent of this temperature rise depends upon the relation between the resistance of the conductor and the strength of the current, and also upon the duration of the current and the effective radiating surface of the conductor. If the heat has a chance to escape by radiation as fast as it is generated, the temperature of the wire remains constant; but, on the other hand, if more heat is supplied by the current than can be disposed of by radiation the temperature of the wire rises, and if the current is great enough and is applied long enough, the wire may finally be melted. These statements apply to any form of electrical conductor—a circuit wire, the filament of an incandescent lamp, the wire in a magnet coil, etc.

From a consideration of these facts, it is evident that there are two kinds of evils due to excessive current against which electrical apparatus must be protected, namely; overheating of relatively substantial conductors on account of continued excessive currents, and overheating of relatively fragile conductors, with very small radiating surfaces, by protective devices provided to meet these requirements: fuses and circuit-breakers.

The fuse in its simplest form is a wire or strip of soft metal, which melts before the current reaches a point that is dangerous to the remainder of the circuit. Fig. 1 shows a fuse of this description. It consists of a wire, *a*, made of low-melting alloy fastened to two copper or brass terminal pieces or clips *b*, *b*. When subjected to a large current, after a short time the wire melts and thus opens the circuit. Fig. 2 shows a fuse which, instead of a wire, has a flat strip of fusible metal between the terminal pieces. Its action is precisely like that of the one just described. Sometimes, a fuse is enclosed in a casing, which being made of non-combustible material, eliminates danger from fire when the fuse "blows." Fig. 3 shows a fuse of this description. A very small conductor on the outside of the casing, which is connected in parallel with the enclosed fuse, and which is melted at the same time as the fuse, shows when it has melted (or "blown").

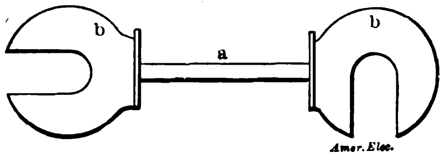

FIG. 1.—FUSE.

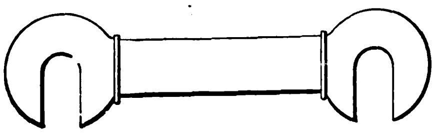

FIG. 2.—FUSE.

A fuse must be inserted in each wire of every circuit; that is, for a two-wire system two fuses are used, and for a three-wire circuit three fuses. Fuses are placed at every point where a change is made in the size of the wire. In Fig. 4, for example, a fuse would be located at each point marked *F*, *f* and f_1; each fuse, however, would be of a different size from the others, except that the fuses marked f_1, would all be alike.

The size of a fuse is determined by the maximum safe carrying capacity of the part of the circuit it protects. Thus in Fig. 4, the fuses marked *F* must not let enough current pass to injure the dynamo, the fuses marked *f* must not let enough

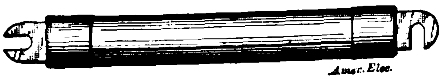

FIG. 3.—ENCLOSED FUSE.

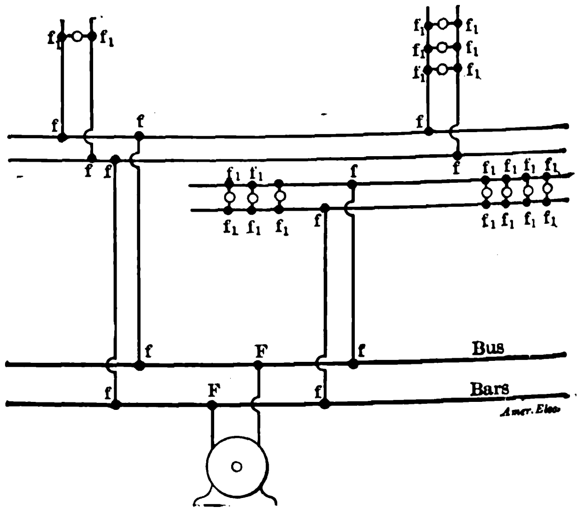

FIG. 4.—FUSED CIRCUITS.

current pass to injure the feeders and finally the fuses marked f_1 must protect the wire in the circuits leading to the individual lamps. In other words, the size of a fuse is determined by the maximum safe carrying capacity of that part of the circuit *beyond* it (reckoning from the source of current) and up to the next fuse. Fuses are arranged to melt at about 25 per cent more than the regular circuit current.

TABLE I.

	Minimum separation of nearest metal parts of opposite polarity.
125 volts or less:	
10 amperes or less	¼ inch
11 to 300 amperes	1 inch
300 to 1000 amperes	1¼ inch
126 to 250 volts:	
10 amperes or less	1½ inches
11 to 100 amperes	1¾ inches
101 to 300 amperes	2 inches
301 to 1000 amperes	2½ inches

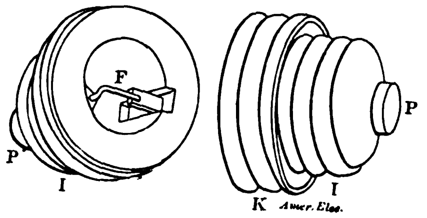

FIG. 5.—CUT-OUT.

Table I shows the proper spacings for unenclosed fuses mounted on slate or marble bases. There must be a space between fuse terminals of the same polarity of at least ½ inch for voltages up to 125 and of at least ¾ inch for voltages from 126 to 250; and greater separation should be provided, if possible.

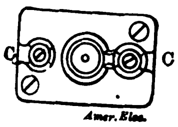

FIG. 6.

Fuses are mounted on insulating bases, usually of porcelain. Such an arrangement is called a "fuse-block" or "cut-out." A simple form is shown in Fig. 5; it is called a "plug" cut-out, and is shown with the cover off at the left of the cut. The fuse is shown at *F;* one of its ends is connected to the outside threaded portion, *I,* and the other to the plug, *P,* at the bottom. When the device is screwed into the socket shown in Fig. 6, contact is made respectively by the plug at the bottom and the threaded part on the outside with the two ends of the circuit wire, which are attached to the base and held in place by the clamps *C, C.* Thus, connection is made between the two ends of the wire through the fuse; under the influence of an excessive current, this melts and opens the circuit. A screw cap, *K,* shown in position at the right of Fig. 5, prevents the melted metal from flying out when the fuse blows. This form of cut-out is used for light currents; one must be placed in each wire of the circuit.

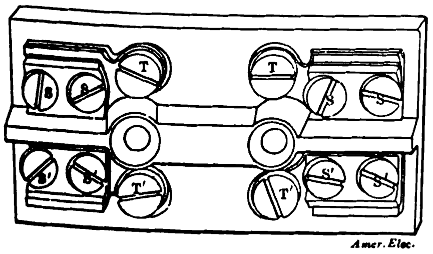

FIG. 7.—MAIN LINE CUT-OUT.

For larger cut-outs, both fuses are mounted on one block. Such a device is called a "main-line" cut-out; it is shown, with the cover removed, in Fig. 7. The ends of the circuit wires are held in place by the screws *S* and *S'.* One of the fuses is fastened between the screws *T, T,* and the other between the screws *T', T',* so that each side of the circuit is protected by a fuse.

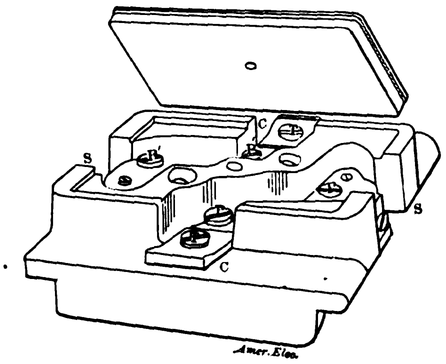

FIG. 8.—BRANCH BLOCK.

When taps are to be made at right angles to the mains, a style of cut-out, called a "branch-block," is used. It is shown in Fig. 8 with the cover raised. The principle of its arrangement is the same as for the last case, except that the wires do not have to be cut. The mains are carried through the base and held securely under clips by binding screws *S, S.* The branch wires are held in place under clips, *C, C,* by the screws, *T, T.* It will be seen from the cut that the branch and main wires are carried through the block at different levels, so that they will not be close together where they cross. The fuses are held in place by the screws, *P, P,* and *P', P',* and serve to make connection between the main and branch wires on either side of the circuit. For the sake of clearness, a diagram of the connections is given in Fig. 9.

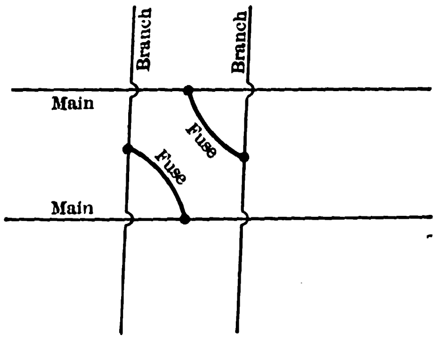

FIG. 9.—BRANCH BLOCK CONNECTIONS.

For protection against overloading due to excessive currents of short duration, a device known as a "circuit-breaker" is used. A simple form of circuit-breaker is shown in part section in Fig. 10. The current passes through the solenoid coil, *B,* and tends by magnetic attraction to draw the movable plunger, *C,* upward into the coil. As the current increases, the attraction increases correspondingly, and finally when it becomes great enough to overcome the weight of the plunger, the latter is caused to strike against the push pin, *E,* which in turn strikes the trigger, *N.* This releases first the switch arm, by the displacement of the retaining latch, *F;* next, the upper part, *H,* of the trigger strikes the plate, *K,* and starts the movement of the switch arm. This movement is continued by means of the spring, *O,* which acts through the plunger, *J,* against the plate, *K,* on the switch arm and pushes it beyond the point at which the contact is broken and the circuit is opened. The final break is made between carbon plates, in order that the arcing may not take place between the copper terminals and injure them. When, however, the circuit-breaker is entirely closed, contact is made between the copper plates, because the conductivity of copper is much greater than that of carbon, and also for the reason that better contact can be obtained with copper. The screw, *M,* at the

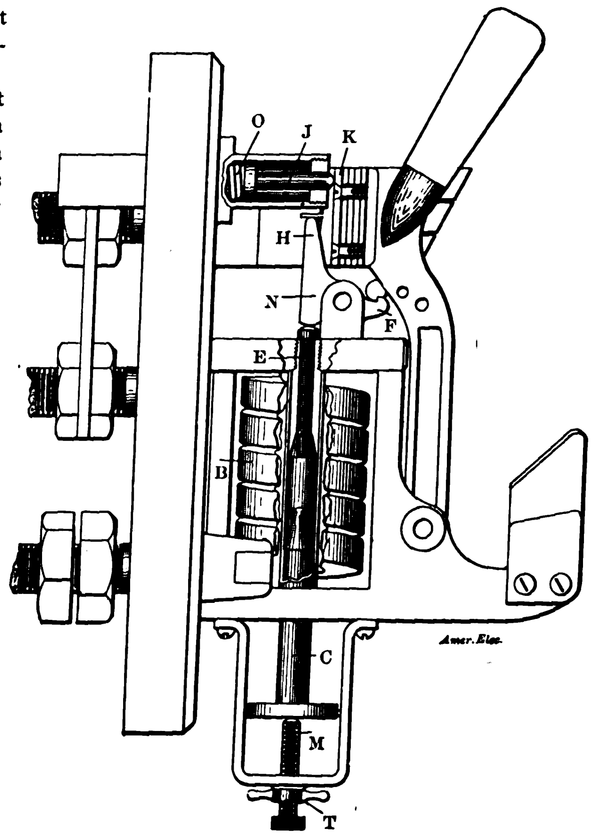

FIG. 10.—CIRCUIT-BREAKER.

lower part of the device is used to adjust the plunger so that it will operate at the desired current strength; the farther up the plunger, the less the current required to make the circuit-breaker open. The lock nut, *T*, serves to hold the adjusting screw in place.

A double-pole circuit-breaker is shown in Fig. 11. Its mode of operation is precisely the same as that of the one just described, the only difference between the two being that the one shown in Fig. 11 has two poles while that of Fig. 10 has only one. The adjusting device is shown more clearly in the cut of the two-pole circuit-breaker than in the other. The numbers show the amperes at which the circuit-breaker will operate. As shown in the figure, it is set to open at 200 amperes. The carbon plates between which the contact is broken may be seen at the top of the side elevation, which is shown at the left-hand side of the cut. Just below are the copper contact pieces, which carry nearly all of the current when the circuit-breaker is entirely closed.

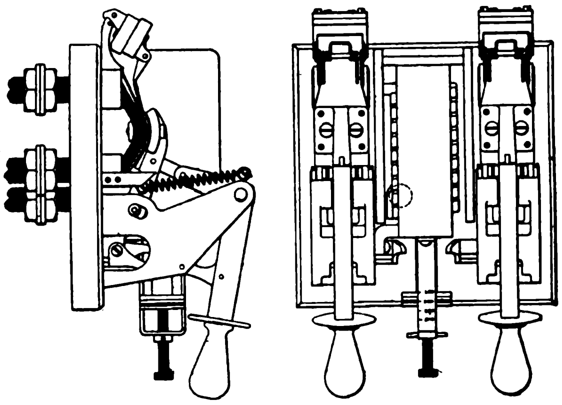

FIG. 11.—DOUBLE-POLE CIRCUIT-BREAKER.

Three-pole circuit-breakers are used for three-wire circuits, and are similar to the two-pole apparatus just described, with the exception that they have three poles instead of two.

Circuit-breakers are also arranged so that, in addition to operating under the influence of excessive current, they will act when the current is entirely interrupted or is reduced to a certain minimum amount. Those of the first class are used on motor circuits, so that if the current is cut off and the motor comes to rest, it will not be injured when the current is again thrown on before the starting resistance is in. Those of the second class are intended for storage battery protection, and operate on either a short-circuit or when the current reaches the smallest value at which it is safe to operate the battery.

Letters on Practical Subjects

Mr. Merrick's Problem in Switches.

To the Editor, American Electrician:

Referring to the three answers to my problem of switches, which were published in the July number of the AMERICAN ELECTRICIAN, I beg to say that only one of these would fill the requirements. With either one of the other two arrangements, if a person were to light the lamps on the first and second floors and his room were on the second floor, he would have to leave the switch open in order to extinguish the lights, and this would prevent any one coming in later from lighting them.

It might be well to put the question again, so that it may be better understood. In a four-story lodging house, it is required to have the hall lights so connected that a person coming in can light the lamps on the floor he is on and the one above, and either extinguish them from the floor above or extinguish those on the first floor and light those on the floor still above him. For example, if a person desired to go to the third floor it must be possible for him on entering to light the lamps on the first and second floors; on reaching the second floor, to extinguish the lights on the first floor and light those on the third, and on reaching the third floor to extinguish all the lights, but to leave the switches so that any one else coming in later can control the lights in the same way. If necessary, two sets of lamps may be used and two or three mains connecting the various floors, but the preference is to use only one switch on each floor.

U. S. S. Columbia. G. H. MERRICK.

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Improved Commutator Construction.

To the Editor, American Electrician:—

The accompanying sketch illustrates a suggestion as to commutator construction which appears to the writer to embody several advantages in comparison with the ordinary style of construction. With the exception of the under-cut commutator, which has many disadvantages, the construction here shown requires less room than any other. Instead of using the customary cast-iron shell and clamping ring, the segments are clamped between two circular drop-forgings, cross-sections of which are identical and of the shape clearly shown by the sketch. The use of drop-forgings instead of castings obviously reduces the space required parallel with the shaft beyond the extreme tips of the segments; moreover, since the drop-forged clamping rings are identical and the clamping is done by means of bolts, a single size of drop-forging may be used for commutators of any length so long as the diameters are the same, it being only necessary to vary the length of the bolts as the commutator lengths vary. The construction here shown has the additional advantage of light weight as compared with the cast-iron commutator shell, and is also a very cheap one, since the drop-forgings require no machining except trueing up the hole for the shaft and drilling the holes for the bolts. It is not absolutely necessary even to machine the shaft hole; if it is drifted out on a drifting press it can be made sufficiently accurate for all practical purposes.

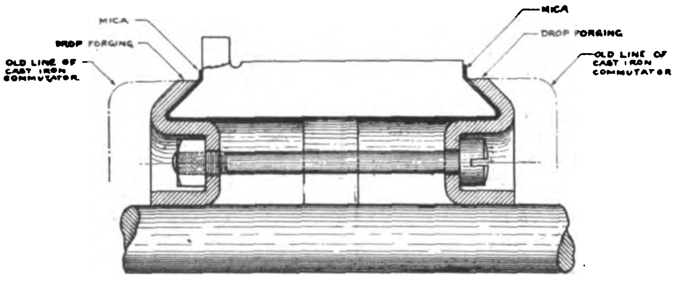
MICA
DROP FORGING
OLD LINE OF CAST IRON COMMUTATOR
MICA
DROP FORGING
OLD LINE OF CAST IRON COMMUTATOR

FIG. I.—IMPROVED COMMUTATOR CONSTRUCTION.

Chicago, Ill. WALTER BROWN.

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Some Points in Arc Lamp Operation.

To the Editor, American Electrician:

Some readers of the AMERICAN ELECTRICIAN may be interested in the methods of arc lamp operation which have been adopted by the Utah Light & Power Company in this city. Our chief electrician some time ago decided to substitute alternating-current long-burning arc lamps for the series arcs in use in the center of the city, the incandescent system being three-phase alternating. The secondary system is very complete and covers the city thoroughly. In order to make the change the series arc lamps were taken out and new series circuits inserted and switches for controlling the alternating-current arcs were connected up to the secondary mains singly. Each switch controls four lamps. The switches are electromagnetic and are enclosed in weather-tight boxes located conveniently near to the lamps controlled. The energizing series circuit is connected by means of a simple knife switch to a 250-volt direct-current circuit for a few seconds, and the automatic switches cut in the arc lamps. Then the control circuit is opened and left open until it is desired to put the lamps out, when the switch is again closed for a few seconds and the automatic switches throw out the arc lamps. The secondary system is four-wire, the lamps being connected each from the neutral to one of the main wires. The automatic switches are simple solenoids, arranged to close and open alternately a knife switch controlling the arc lamp circuits. This arrangement has been found very reliable and enables the station to control fifty 6½-ampere arcs without separating the commercial from the city lighting circuits.

DANIEL B. MCBRIDE.

Salt Lake City, Utah.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Are reversing engines used at all in power plants? S. K. G.

If you refer to electrical power plants, no.

What is a good varnish for copper? G. H. N.

Carbon disulphide 1 part, benzine 1 part, turpentine 1 part, methylic alcohol 2 parts, gum copal 1 part.

Is steam used expansively in the steam turbine? (2) Why are all steam turbines operated condensing? A. N. U.

Certainly; its expansion could not be prevented even if desired. (2) For the same reason that all large reciprocating engines are: to increase the economy.

Is it necessary to change a shunt-wound motor to a series-wound machine in order to adapt it to blower driving? F. J. F.

No; a shunt-wound motor will operate a blower as satisfactorily as a series-wound machine, and in most cases is preferable for this class of work.

What is the approximate relation between the cross-sectional area of different sizes of wire drawn to B. & S. gauge? I. D. V.

The area of each size is approximately 79 per cent of the area of the next larger size; and any given size has roughly one-half the cross-sectional area of the size three gauge numbers larger.

What change is necessary in order to adapt a 110-volt fan motor for operation on a 125-volt circuit? A. R. Y.

None, if the difference in the voltage is the only difference in operating conditions. The motor will run slightly faster and take a little more current at the higher voltage, but not enough to overheat it.

Can a group of lights be controlled independently from more than two points by the use of three-point switches? C. E. B.

No; three-point switches can be used at two of the control places, but all others must be four-point switches. This arrangement was fully described in the December, 1901, issue of this paper.

Is it possible to use an ordinary alternator as a synchronous motor, driving it electrically from a similar machine? (2) A small compound-wound direct-current motor reverses and throws off the belt when the load goes beyond a certain point; what is the cause? E. L. W.

Yes. (2) The series winding is evidently connected up differentially, and when the current exceeds a given strength it neutralizes the effect of the shunt winding and reverses the field magnetization.

How can I ascertain what power factor gives the smallest energy consumption in a distribution system supplying both induction and synchronous motors; the power factor being adjustable, of course, by varying the excitation of the synchronous machines? M. V. W.

Measure the power factor and true power simultaneously when running at the average load and vary the power factor until minimum power is indicated by the wattmeter or wattmeters.

Why are not alternators operated in series for obtaining very high potentials, so as to avoid transformer losses? (2) At what point on the curve representing the alternating-current or e.m.f. wave does the sign change from positive to negative and vice versa? L. T. J.

Because it is impossible to keep two or more machines in phase when in series. (2) At the datum or zero line; no force can reverse its direction or sign without first coming to zero value.

In an alternating-current circuit having a large wattless component (low power factor) does not the lag of current reduce the current in one direction and increase it in the other? (2) If so, will not a shunted direct-current ammeter indicate the true power component. R. W. O.

Not at all; nor does it produce any result in the least similar to this. A current cannot reduce itself, and two currents cannot pass in a single conductor simultaneously. (2) No.

Why are not steam injectors better for boiler feeding than ~~more complicated and expensive~~ pumps? (2) If pumps are very much preferable, why are injectors used? J. D. W.

Because they cannot be regulated to the same extent; also because of their inability to lift water with certainty from as great a depth. (2) As a reserve, in stationary engineering practice; because of the small space occupied and the absence of lift, in locomotive practice.

What is a good method of "pig-tailing" a carbon brush? P. S.

Drill a ¼-inch hole through the brush near the upper end; fit a brass bolt snugly to this hole; solder the "pig-tail" to the head of this bolt, and secure the bolt to the brush by means of a nut and washer on the front face of the brush. If the brush-holder has no slot down the front of the box to accommodate the nut, the latter must be countersunk flush with the face of the brush.

Why cannot magnetism be insulated? (2) Is magnetism a force or a condition? H. E. O.

Because no substance has yet been discovered which is opaque to magnetic force. (2) Neither; the iron of an electromagnet, for example, is in the condition known as "magnetized" when subjected to the "magnetic force" or stress set up by the electric current in its exciting coil. It is difficult to define magnetism; it comes nearer being the "manifestation of a force" than anything else comprehensible.

Which part of a dynamo field magnet is most highly magnetized in ordinary practice? (2) Which is preferable for lighting service, an evenly compounded or an over-compounded dynamo? (3) Every other commutator segment of a motor blackens slightly; there are twice as many coils as armature slots; could this cause the trouble? M. K. S.

The core, or portion surrounded by the winding. (2) A slightly over-compounded machine is usually preferred, unless the drop in the distribution system is very small—less than 5 per cent. (3) It might; if the slots are very deep and narrow, and one coil is nearer the bottom than the other, the difference in the inductance of the two might be sufficient to cause the result described.

What is the rule for calculating the percentage of error in a watt-meter when tested with a voltmeter and ammeter. (2) Knowing the volt-amperes in the primary circuit of a constant-current transformer supplying a series arc circuit, how may the power factor of the secondary circuit be calculated? B. E. L.

The instruments used in testing do not affect the rule. If the available test circuit is alternating, you cannot check the wattmeter with a voltmeter and ammeter; a standard wattmeter must be used. The formula, irrespective of the instruments used in checking, is:

$$100\,\frac{\text{Difference in readings}}{\text{True reading}} = \text{Per cent error.}$$

(2) There is no relation between the two; the power factor can be determined only by measurement in the secondary circuit.

I wish to construct a resistance for charging storage batteries. The generator gives 12 amperes at 50 volts, and I desire to keep the resistance frame as small as possible. What size of German silver wire ought I to use, and how much of it would I require to reduce the current down to charge a 4-volt storage battery, the charging rate of which is given as 1.5 amperes for 10 hours? Would 3 amperes for 5 hours be detrimental to the plates? A. F. S.

As the current required is 1.5 amperes and the voltage of the supply is 50, the necessary resistance would be 50 ÷ 1.5, or approximately 33 ohms. Therefore, 33 ÷ 0.23, or 144 ft. of No. 20 B. & S. German silver wire would be required, it having a resistance of 0.23 ohm per foot. Three amperes for five hours might tend to buckle the plates of your battery.

When an armature is out of center in a dynamo or motor, is it magnetically or mechanically unbalanced? (2) If not, what constitutes a state of magnetic unbalance and mechanical unbalance? (3) If the armature is nearer one field magnet pole than the others, will the bearings wear more on that side than elsewhere? (4) Assuming that a commutator can be adjusted around the shaft without breaking the armature leads, is the effect of twisting it the distance of one segment forward or backward the same as though the brushes had been shifted the same distance in the same direction? (5) Are series coils wound from right to left on alternate poles and from left to right on the intermediate poles? C. O. M.

Not necessarily. Magnetic unbalancing is not an armature condition. (2) When the field-magnet poles of a machine are not all of the same strength, the machine is magnetically unbalanced. When the center of gravity of an armature does not coincide with its structural center, the armature is mechanically unbalanced. (3) Yes. (4) No; the effect is the same as though the brushes had been shifted the same distance in the opposite direction, the commutator remaining fixed. (5) Magnet coils are usually wound all alike and connected up so that the current circulates about alternate poles in the same direction.

VOLTMETER COMPENSATOR.

The voltmeter compensator is an instrument designed for use in connection with the station voltmeter, so that the latter will indicate the voltage at the center of distribution, instead of the voltage at the station. It replaces the old method of running back pressure wires from the center of distribution to the station voltmeter, which system may become very complicated where a number of circuits are employed.

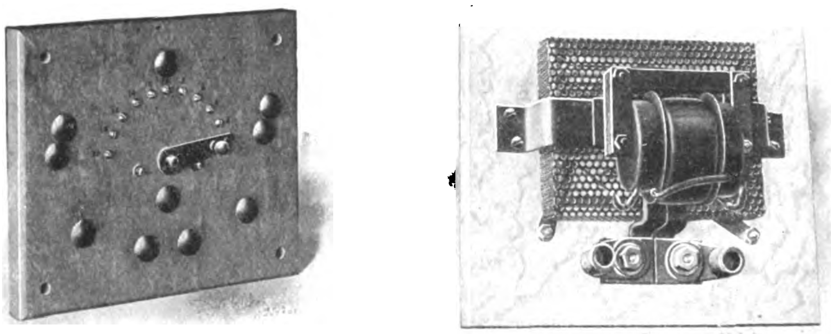
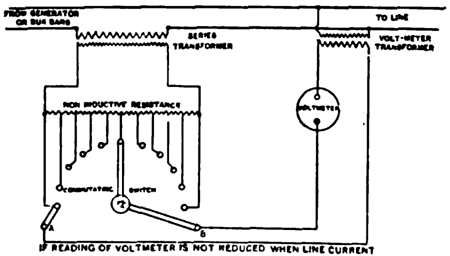


FIG. I.—FRONT AND REAR VIEWS OF VOLTMETER COMPENSATOR.—FIG. 2.

As is well known, the drop in a non-inductive circuit depends directly on the current, the length of the line and the size of the wire. It can therefore readily be seen that, where a number of lighting circuits, varying in length, size of wire and load, are run from the same generator or generators in parallel; with the use of separate circuit regulators and voltmeter compensators, the regulation of each circuit can be made independent of the others and the voltage at its center of distribution thus kept constant independent of the voltage of the generator or bus-bars.

The instrument is designed for use with the hot-wire voltmeter and to compensate for line losses of 0 to 20 per cent. It can be set for, and will operate at a given power factor, but its mission does not include compensation with a variable power factor.

The instrument consists of a series transformer, an adjustable resistance and a special commutating switch, all mounted on one slab of marble, as shown in Figs. 1 and 2. The series transformer is designed with the primary winding to carry the maximum current of the circuit, inducing electromotive force of 20 volts on the secondary winding. The adjustable resistance is connected across the secondary of the series transformer. It has taps brought out to give a regulation in 2 per cent steps, the taps being connected to the points of the special commutating switch.



IF READING OF VOLTMETER IS NOT REDUCED WHEN LINE CURRENT INCREASES REVERSE CONNECTIONS A & B

FIG. 3.—DIAGRAM OF CONNECTIONS.

The connections of the compensator, in conjunction with the voltmeter and voltmeter transformer, are shown in the accompanying diagram, Fig. 3, the resistance of the compensator being connected in the voltmeter circuit so that the voltage across it is in opposition to the voltage on the secondary of the voltmeter transformer.

If the drop in the line is known, say 10 per cent at maximum current, and a pressure of 100 volts is desired to be kept on the lamps at the center of distribution, the voltmeter at the station would have to read 110 volts at full load. By placing a compensator, which is designed to give 20 volts at maximum current on the line, in the circuit and setting the switch at the central point, 10 volts will be in opposition to the voltage of the secondary of the voltmeter transformer and the voltmeter will read 100 volts, which is the voltage at the center of distribution.

By regulating the voltage impressed on the circuit at the station end, so that the voltmeter always reads 100 volts, the voltage at the center of distribution will be kept constant at 100 volts, no further adjustment of the switch being necessary. This is due to the fact that the voltage on the adjustable resistance is directly proportioned to the current in the primary of the series transformer. Thus, if half the maximum current is flowing, the line loss will only be 5 per cent and the voltage impressed on the circuit at the station end would therefore only have to be 105 volts as read by the voltmeter. At half the maximum current the voltage across the resistance is only 10 volts, and the switch still remaining at the central point will reduce the voltmeter reading by 5 volts, thus making it indicate 100 volts.

In order to facilitate the setting of the switch, each point is marked with the number of volts that the compensator will reduce the voltmeter reading at the maximum current. If the drop in the line is not known, the switch may be set by taking the readings of the voltage at the center of distribution. Standard compensators for any capacity up to 300 amperes are supplied as illustrated with the series transformer attached to the instrument. For greater currents the transformer is supplied separate and mounted on the station bus-bars. The instrument is made by the Stanley Electric Manufacturing Company, of Pittsfield, Mass.

HEATING AND VENTILATING EQUIPMENT.

The Pennsylvania Steel Company has recently erected at Steelton, Pa., a large shop and office building which is equipped with a Sturtevant heating and ventilating outfit of the latest and most modern design. In the bridge and construction shops there are eight fan and heater equipments. The heaters are built on patent corrugated cast iron sectional bases with 1-inch steam pipes set staggered. The fans are enclosed in three-quarter steel plate housing and are driven by direct-connected horizontal engines. The air is distributed in galvanized iron pipes discharging through branch drop connections having outlets near the floor. Each drop pipe is fitted with a butterfly damper with a counter-weight for holding it in any desired position. The apparatus changes the air in the paint shops every 20 minutes, and in the other shops every 25 minutes. The office building is heated by the same method, 21,430 cubic feet of air per minute being discharged into rooms having a total capacity of 289,763 cubic feet, thus providing for a complete change of air every 15 minutes. The fan for the office building heating plant is motor-driven.

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A LARGE COMMUTATOR.

The accompanying photograph illustrates the assembly of a commutator which is to form part of an 1800-kw. direct-current generator under construction in the shops of the British Westinghouse Company, Manchester. The generator is being supplied to the order of the City of London Electric Lighting Company, and will be operated in conjunction with units of similar size already supplied by the Westinghouse Company, and working at the Bankside Station. The external diameter of the commutator is 10 feet, and there are 900 segments of hard-drawn copper. The generator is designed for a normal output of 1800 kilowatts at 500 volts, and will be capable of carrying a continuous overload of 20 per cent.

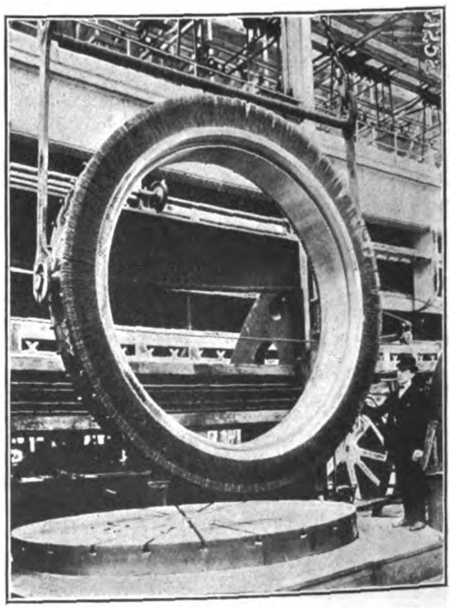


FIG. I.—COMMUTATOR FOR 1800-KW. GENERATOR.

New Apparatus and Appliances

MILLER INCANDESCENT LAMP.

An ingenious incandescent lamp which embodies many novel features is shown by Fig. 2 herewith. This is manufactured by the Missouri American Electric Company, of St. Louis, Mo., and is known as the Miller patent incandescent electric lamp. The patent consists in the manner of attaching the base and the locking device of the button, the button being firmly seated on the neck of the lamp. The cap is slipped over and prevented from lateral rotation by the button, and against withdrawing by a wire clamping it to the shoulder blown in the neck. This is clearly illustrated in Fig. 1, which shows the various parts. The operation is wholly mechanical and eliminates the use of any plaster of paris or cements and avoids the practically total loss of the entire lamp after the filament has burned out. By this construction, when the filament is burned out, by cutting the neck at the narrow part below the cap the steam may be withdrawn and a new filament attached to the leading in wires by the original process. The parts are again fused and the lamp exhausted of air. In rebuilding the lamp the original bulb may be cleaned and again used, or a new bulb may be fused on if required. In any case, the button, sleeve stem, and labor on same can be saved. The lamps are made with the anchor oval type of filament and Edison base, although the company expects to manufacture other types of filaments and bases.

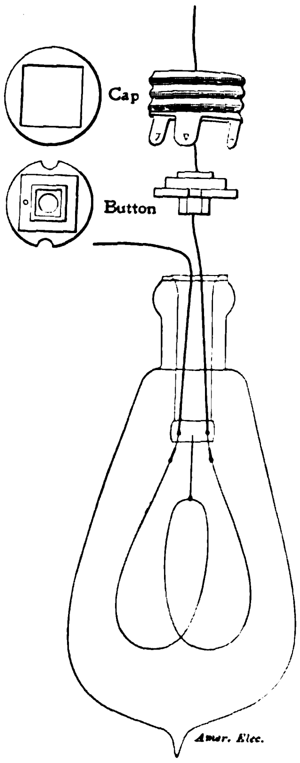


FIG. 1.—MILLER INCANDESCENT LAMP.

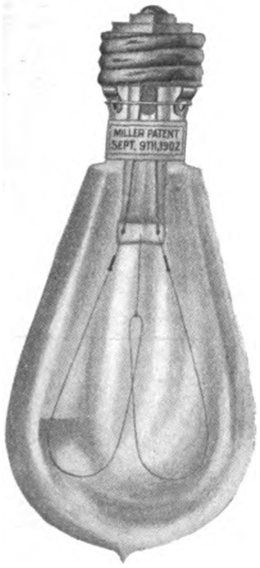


FIG. 2.—MILLER INCANDESCENT LAMP.

THE VICTOR LOW-PRESSURE STEAM TRAP.

A new steam trap especially designed for low-pressure service, has just been brought out by the Wright Manufacturing Company, of Detroit, Mich. As is generally known, such service requires a large valve area in a steam trap, owing to the large quantities of condensation which the trap is called upon to handle. By noting the accompanying sectional illustration it will be seen that this requirement is provided for in the "Victor" by a valve whose area is approximately equal to that of the pipe at inlet and outlet. The makers claim the smallest size of the Victor steam trap is capable of discharging 350 gallons of condensation per hour, and the largest size 8,000 gallons per hour, at a steam pressure of three pounds in both instances. There are seven intermediate sizes, making nine sizes in all. Another novel feature in the Victor steam trap is claimed to be its ability to operate perfectly under no steam pressure whatever, the pressure of the incoming condensation being alone sufficient to open the valve. The extreme pressure at which these traps are intended to operate is 20 pounds. In operation, the trap is very simple. The condensation enters the trap, filling it to the level of the valve, when the float is raised by the incoming condensation. At the same time the valve is floated, or lifted, from its seat. The trap then delivers the condensation, continuing to discharge until the inflow of condensation ceases, when the float in descending, closes the valve. The other features of this trap may be briefly summarized. A very deep water seal covers both inlet and outlet, preventing leakage of steam. The blow-off serves to keep the trap free from sediment, although the latter could hardly interfere with the working of valve, owing both to its large size and its location near the top of the trap. A water gauge is also provided, to which an air valve is attached for venting the air when the trap is working under very low pressure. The valve and valve seats, may be removed easily with a screw-driver and wrench. As the working parts are attached to the cap, they may be removed without disturbing the piping. The float is round and seamless.

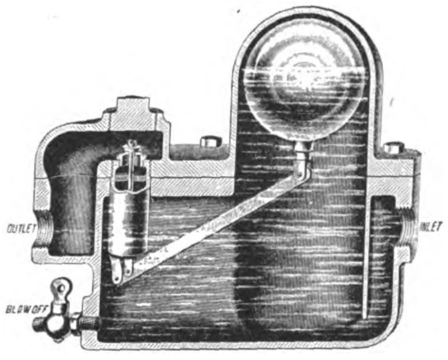


FIG. 3.—VICTOR LOW-PRESSURE STEAM TRAP.

ENGBERG ELECTROHYDRAULIC VALVE.

Fig. 4 herewith illustrates an electrohydraulic valve made by the Engberg Electric and Mechanical Works of St. Joseph, Mich. The gate valve is operated by an hydraulic cylinder supplied with water from the main and having connections from both sides of the main valve so as to always supply water to the hydraulic cylinder from the high pressure side. The regulating valve consists of a flat three-way valve which is operated by a piston. The piston is operated by two poppet lift valves which are raised from their seat by an armature and magnet. By pushing a button at the pumping station the armature on the controlling device lifts one of the small poppet valves thereby permitting the water to escape on one end of the piston which then moves toward the end and opens the port to the hydraulic cylinder. When the button is released the poppet valve is closed.

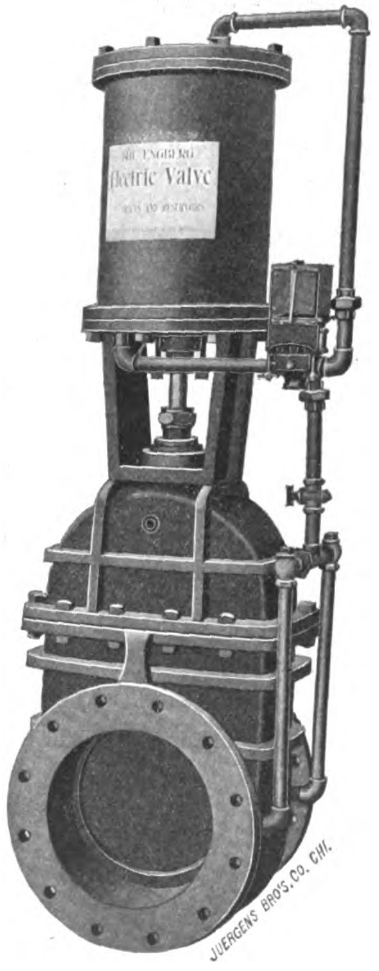


FIG. 4.—ENGBERG ELECTROHYDRAULIC VALVE.

This opens the main valve. At the same time as the break in the circuit the armature drops down and engages the other poppet valve, and when the button is pressed again opens this one and allows the piston to travel to the opposite end, which opens the port to the opposite end of the hydraulic cylinder, thereby closing the main valve again; viz.: pressing the button once opens the main gate; pressing it again closes the same. The electric hydraulic attachments can be attached to valves already in the mains by bolting the center castings to the stuffing box on valve bonnet, The controlling device requires but one line of wire, the ground being used for return. The valves are furnished with push buttons and batteries.

A NEW DEVELOPMENT IN LIGHTNING ARRESTERS.

Whenever alternating current circuits contain both inductance and capacity in appreciable quantities, high voltages are likely to exist which endanger the insulation of the whole system. Such abnormal voltages are especially likely to occur in lines containing a combination of underground and overhead circuits. The General Electric Company is now supplying alternating current lightning arresters so designed as to protect against lightning and at the same time to act as a safety device with reference to high voltages due to causes other than lightning. These high voltage conditions in a great many cases may not be recognized by the central station manager unless they are brought to his attention by the frequent breaking down of insulation, and even then the troubles are often ascribed to other causes. The strains very often produce pin-hole punctures in the insulation of underground cables and thus relieve themselves temporarily; they may therefore remain unnoticed for a number of months until the insulation becomes very much impaired, ultimately resulting in a complete breakdown. It is very difficult to detect the existence of these excessive voltages with switchboard instruments commonly in use. In the first place, most voltmeters are installed on potential transformers. When these abnormal pressures exist, the wave is of enormous high frequency and will not appear on the secondary side of the transformer, due to the fact that the eddy current set up in the iron by the high frequency is so great as to dampen out the wave and prevent its reappearance on the secondary side, but it is difficult to measure this pressure even with such instruments as electrostatic voltmeters installed directly across the high pressure wires. This is because the wave is of short duration and its integrated value is so small and the time element of the moving mechanism of the instrument is so large comparatively that the instrument will not record the disturbances. Practically it has been found that only spark gaps of some form of wave meter which records instantaneous value is of any service whatsoever for such measurements. The new lightning arrester known as the "Multiplex" performs, it is claimed the multi-function of protecting against lightning, resonance or other high voltage disturbances on the line. The arresters are installed directly across the lines, the center of the arrester being connected through an additional installation of arresters, so proportionate that there are the same number of gaps from either line to line as from line to ground.

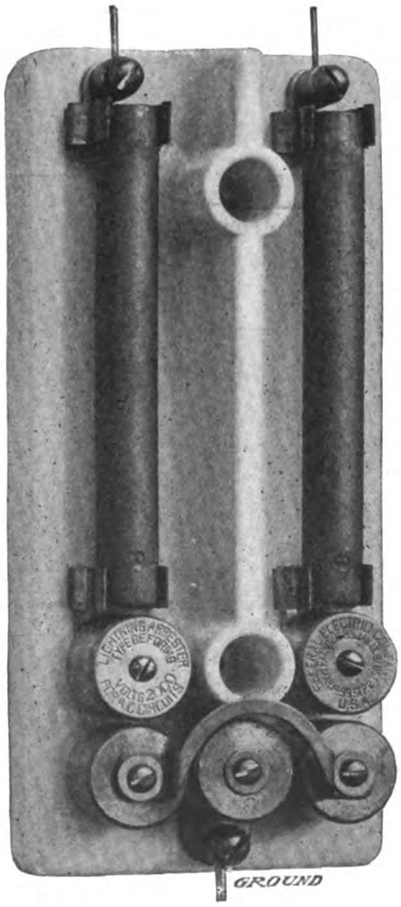


FIG. 5.—LIGHTNING ARRESTER.

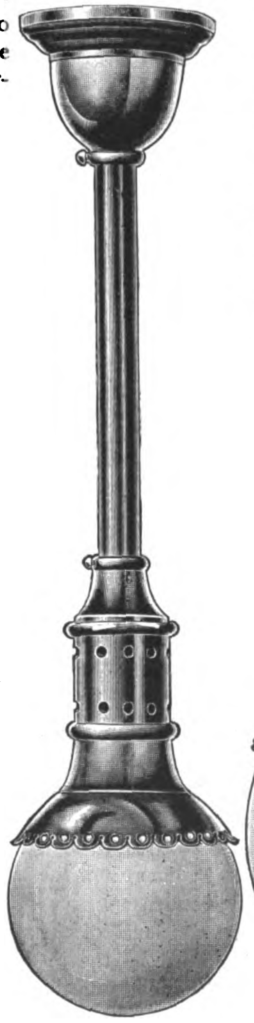
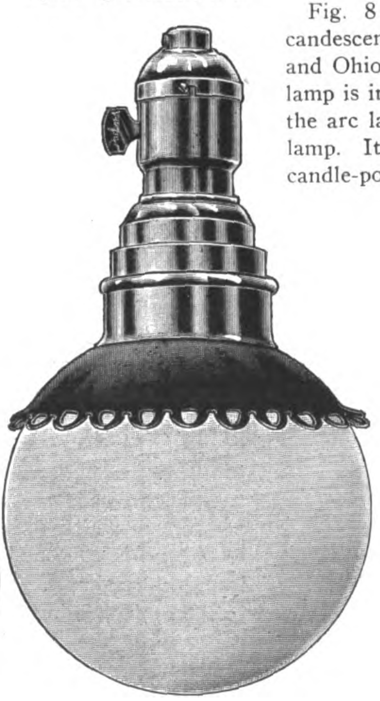


FIG. 7.—ZENITH LAMP.



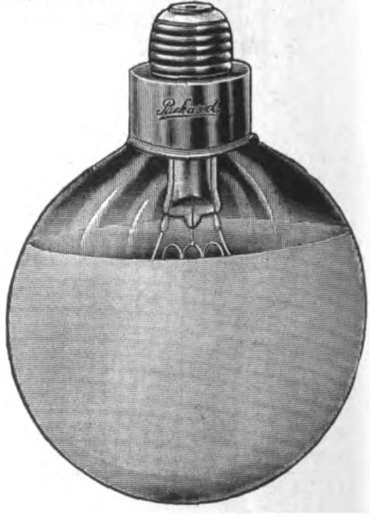


FIG. 8.—ZENITH INCANDESCENT LAMPS.—FIG. 9.

NEW CABLE BRACKET FRAME.

C. M. Gest, of Cincinnati and New York has invented and placed on the market the bracket frame illustrated herewith. The frame is made of angle iron heavily galvanized, and is supplied at the top and bottom with anchors which with the frame itself are built in the wall, the face of the frame being flush with the wall, thereby taking up no room in the manhole. The cable bracket is secured to the frame by means of a galvanized T-head bolt with a special nut so designed that the bracket is removed by being lifted straight up. By means of the special nut the bracket can be adjusted to any angle, and as the slot in the frame is unobstructed from top to bottom the bracket can be adjusted to any height desired. The frames are made in the following lengths: 12-in., 24-in., 30-in., 36-in., 42-in., and the brackets are made in three sizes, single, double, and triple. The bracket bolts are removable at any time and very little time is required to change from a single bracket to a double or triple type.

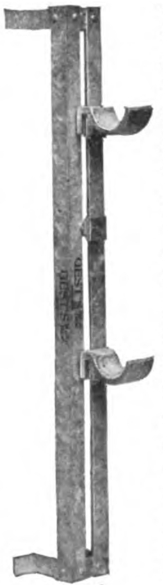


FIG. 6.

ZENITH INCANDESCENT LAMPS.

Fig. 8 herewith shows the Zenith incandescent lamp made by the New York and Ohio Company, of Warren, Ohio. The lamp is intended as an intermediate between the arc lamp and the ordinary incandescent lamp. It is made in two sizes, 25 and 55 candle-power, at efficiencies of 1.9 and 2.5 watts per candle-power, depending on the size and voltage. The lamp gives a particularly brilliant, yet soft, white light, which is evenly distributed beneath the lamp. The range of voltage of this lamp is from 90 to 150, and it is furnished regularly in Edison base, but can be furnished also in T. H. base. The filament is located in the bulb with reference to the polished aluminum reflector which performs an important function. The lamp can be used on either direct or alternating current and requires no attention during its life. The lamp is fitted with a simple collar adapted for use on any style or fixture or furnished complete with ceiling stem as shown by Fig. 7.

SCRANTON OIL FILTER.

Fig. 10 herewith shows a new oil filter which is being placed on the market by the Scranton Oil Filter Company, Scranton, Pa. In this apparatus, the filtering material is composed of wicks, the action being preeminently capillary. Water is used in the outer compartment of the upper chamber, but not for filtering purposes; it is only used to agglomerate and precipitate entrained water which may be held in the oil. The filter is built of heavy galvanized iron with soldered joints, and where seams carry weight, these are both riveted and soldered. An original feature of the apparatus is the ability to double or treble the capacity or any size of filter by the insertion of one or more trays of filtering wicks without interfering with any other part of the filter. As an instance, the manufacturers claim that a 60-gallon filter can be increased to a capacity of 120 gallons by the insertion of another tray of wicks. Fig. 10 herewith shows a vertical section of a single style of filter. In the middle of each filtering tray is constructed a heating chamber in which is placed a heating coil with a heating capacity suited to the requirements of that filtering tray. All of the oil is heated in this compartment before it enters the filtering wicks. The principal members and operating parts of the filter are shown by Figs. 11 and 12, and their general functions may be explained as follows: The receiving tank is composed of the outer tank, *A*, the settling (inner) tank, A^2, the top strainer, or hopper, *D*, drip-pan, *E*, with tubes, *E*, separator, *F*, oil float, *G*, with tubing and piping, and governor or regulating valve, *H*. The filtering tray is composed of the shell, *B*, with chambers in which are placed the filtering wicks, *O*, and the heating compartment in which is placed the heating coil, *J*. The storage tank, at the bottom, receives the filtered oil as it drips from the filtering wicks, whence it is drawn off for use. Other detail parts about the filter are: The collecting pan, *P*, with tube, P^2 (used only in double filters), for collecting and conveying the filtered oil from the upper tray of filtering wicks through a vertical tube past the lower tray and into the storage tank below. *K*, drain cock from inner oil collecting and settling chamber, A^2. *L*, drain cock from water compartment of receiving tank, *A*. Through this cock, the accumulations of heavy impurities and the separated water are drawn off. *M*, drain cock from heating compartment, in wick chamber, *B*. *N*, drain cock from wick basins in wick chamber, *B*. *R*, gauge glass to show water level in outer compartment of receiving tank, *A*.

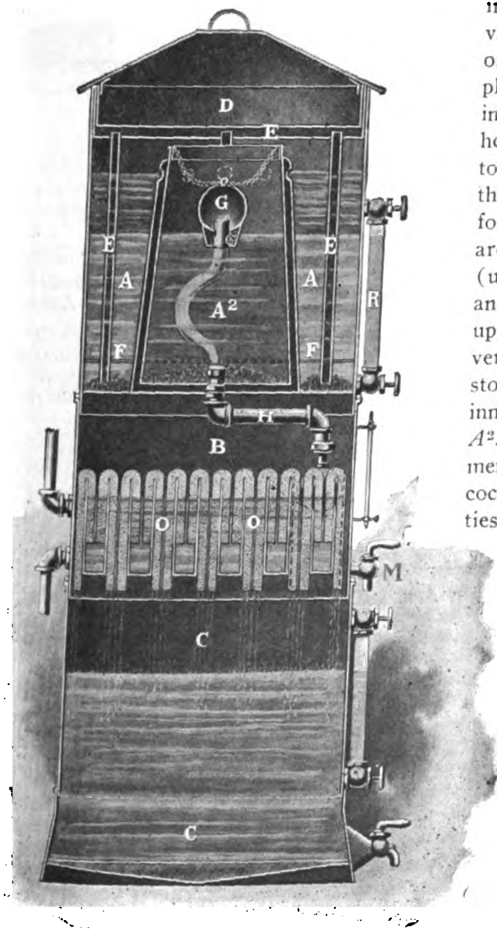


FIG. 10.—VERTICAL SECTION SCRANTON OIL FILTER.

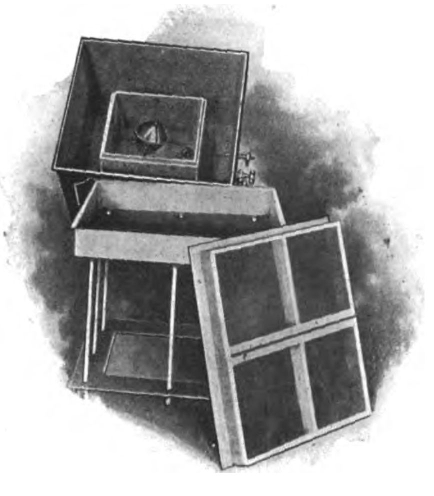


FIG. 11.—HOPPER AND DRIP PAN.

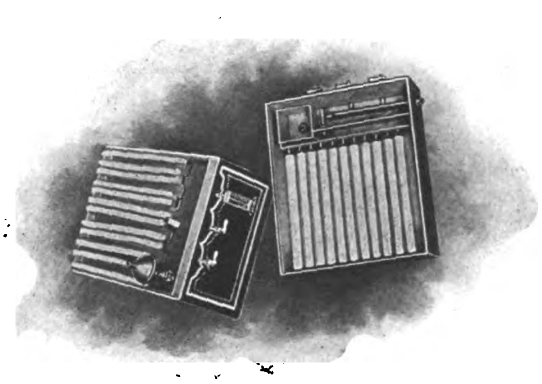


FIG. 12.—FILTERING TRAYS.

NEW BOOKS.

Hardening, Tempering, Annealing and Forging of Steel. By Joseph V. Woodworth, Author of "Dies, Their Construction and Use." Norman W. Henley & Co., 132 Nassau Street, New York, 1903. 208 pages; 201 cuts and diagrams. Price, $2.50.

This work is full to overflowing of practical information about steel. Although some of the receipts and processes seem to retain a trace of the empiricism of the old-time shop practice, the book, as a whole, is well written, and shows the work of one who has not only had vast practical experience, but who has an intelligent grasp of the scientific principles involved. As the title indicates, this book treats of hardening, tempering, annealing and forging in the most thorough manner, besides which there is considerable other incidental information. Thus, in describing the tempering of punches and dies, there is a good deal of general information about this class of tools thrown in. Besides this, Chapter XI is devoted to miscellaneous methods and processes, and contains a number of tables, and Chapter XII treats of emery grinding machinery. We recommend the book to all who are interested in the subject.

Electric and Magnetic Circuits. By Ellis H. Crapper. London: Longmans, Green & Co. Cloth; 379 pages. 5½ ins. x 8½ ins., 62 diagrams and 17 tables. Price, $3.50.

This is intended to serve as an introduction to a course in electrical engineering, and the object of the book, as set forth in the preface, is to explain in a simple way the fundamental principles relating to electric and magnetic circuits, the scope of the work being limited to direct-current circuits. The first three chapters are devoted to electric circuits, the next two to magnetism and magnetic calculations. The subjects of the succeeding chapters are the design of magnet coils, dynamo and motor calculations, dynamo efficiencies, and systems of electrical units. The treatment of the various subjects is too academic for a beginner and too mathematical for a practical man. Some of the data are old and some of the statements of the author misleading. The best feature of the book is a large number of solved illustrative examples. The author states in the first part of the preface that his "experience" leads him to the conclusion "that but few engineers are able to take full advantage of the classical works with which electrical literature abounds, simply and solely because they have not mastered thoroughly the elements of the arithmetic of electrical engineering." If he had obtained the collaboration of some one of the "few" who do know, in the preparation and revision of his book, it would doubtless have been less academic, freer from errors, and more readable and instructive to the large class of engineers for whom it was written.

National Electrical Contractors Association Convention Notes

The Fuller Company was represented by Fred. Vollner and R. Fuller.

Frink Reflectors were not forgotten, through the presence of Mr. Frank Stout.

Ball & Wood Engine Company were represented by Mr. J. H. Parshall, of Detroit.

A. R. Hussey showed a line of telephones, the product of the Allen-Hussey Company, Chicago.

Crocker-Wheeler Company, Ampere, N. J., was represented by Mr. F. S. Blackall, of New York.

Fostoria Incandescent Lamp Company was represented by Chas. J. Wells from the home office.

The Gould Storage Battery Company had Mr. E. L. Draffen, of the Chicago office, in attendance.

The Jewell Electrical Instrument Company, Chicago, had Manager Edward M. Jewell on the scene.

Fort Wayne Electric Works showed a line of arc lamps, meters, etc., in charge of H. L. Searles, assisted by Frank Ross.

The Sprague Electric Company exhibit was in charge of Alex. Henderson, New York, assisted by E. B. Kittle, Chicago.

The Adams-Bagnall Company had Mr. J. G. Pomeroy in attendance talking the merits of A. B. arc lamps better than ever.

The Dale Company exhibit of electric lighting specialties was a most attractive one. Handsome souvenirs were distributed.

Bissell.—The interests of the F. Bissell Company, Toledo, Ohio, were looked after by Fred. Bissell and M. S. Walker.

The National India Rubber Company was represented by C. F. Lyons. They showed samples of rubber covered wire, etc.

American Miniature & Decorative Lamp Company, of New York, was represented by H. Allen Martien of the Chicago office.

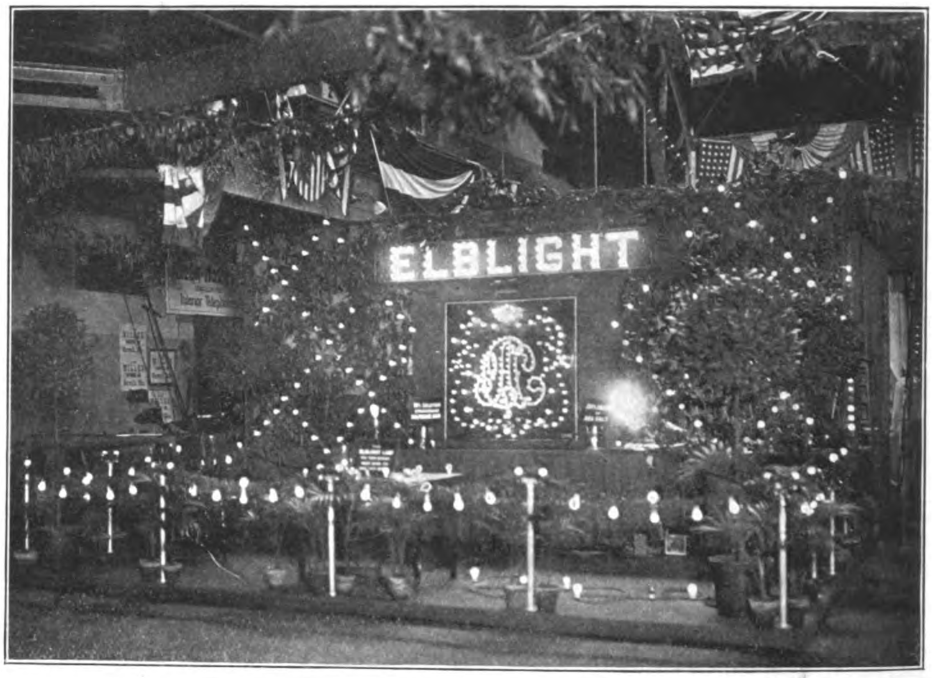
Patrick Carter & Wilkins, Philadelphia, sent W. W. Winship to display their annunciators and some of their house goods specialties.

National Carbon Company had on display its dry batteries, brushes, etc. It was represented by Edmund J. Climo and F. J. Kysela, Cleveland.

National X-ray Reflector Company, of Chicago, was represented by E. L. Haynes. Among the reflectors shown was an attractive cluster.

The Peru Electric Manufacturing Company was somewhat delayed in getting its exhibit in shape. It was represented by R. H. Bouslog and George S. Searing.

George F. Porter, ex-secretary of the National Electric Light Association, was in active attendance in the interest of the Atlantic Insulated Wire & Cable Company.



A BRILLIANT LIGHTING DISPLAY.

Weston Electrical Instrument Company had adequate representation in Major R. Edwards, Jr., C. W. Cobb, E. R. Field and L. J. Baldwin.

The Benjamin Electric Manufacturing Co., of Chicago, was represented by R. B. Benjamin, manager. They exhibited their line of clusters and electric specialties.

R. B. Corey talked for his several lines made by Hart & Hegeman Manufacturing Company, Bossert Electric Construction Company and American Circular Loom Company.

S. B. Condit, Jr., & Co., Boston, sent Fred. W. Nason, who kept busy talking the merits of Elden circuit-breakers, and explaining the good points of their laminated type.

Browning Manufacturing Company, Milwaukee, showed a line of dynamos and motors. They were well advocated by S. A. Bean, of the head office, and H. B. Wilkins.

The Norden-Bittner Electric Company, of New York, was represented by Mortimer Norden, who explained the company's changeable electric signs to the various contractors.

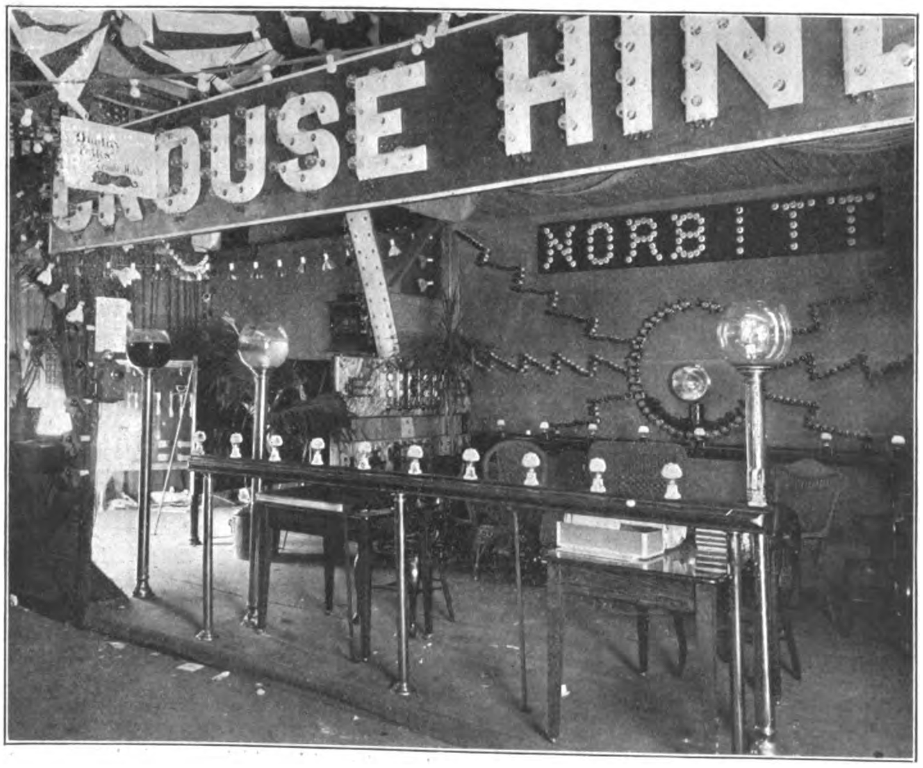
The Johnson & Morton Exhibit was one of the centers of attraction. It was in charge of W. H. Morton, the popular secretary of the National Electrical Contractors' Association.

The Phelps Company, of Detroit, had their customary attractive exhibit of Hylo lamps. Their new self-flashing lamp, which has attracted considerable attention was advantageously shown.

American Circular Loom had a handsome exhibit and were ably represented by H. B. Kirkland, Jas. L. Kirkland, R. B. Corey, T. H. Bibber and T. G. Grier. Handsome buttons were distributed.

Marshall-Sanders Company, of Boston, was represented by L. W. Kittman. Their exhibit consisted of their line of push button switches, plugs and receptacles and baby knife switches with slate base.

The Electrical Appliance Company, of Chicago, was looked after by S. A. Rall and W. P. Upham. Aside from their general line of supplies they exhibited the Toler conduit system, and the Zenith lamp.



AN ATTRACTIVE EXHIBIT OF PORCELAIN INSULATORS.

Nernst Lamp Company had on hand T. H. Bailey Whipple, Pittsburg, and A. F. Fleming, Chicago, to talk the merits of the lamp.

Bossert Electrical Construction Company, of Utica, N. Y., was represented by F. T. Foxenberger. A 1250 ampere switch was shown.

The Hart Manufacturing Company, of Hartford, Conn., was represented by William Taylor, manager of the New York office. They exhibited the famous "Diamond H" switches and samples of sheet mica.

Pass & Seymour, Solvay, N. Y., were represented by B. E. Salisbury, general manager; J. W. Brooks, of Chicago, and W. Brewster Hall, of New York. They showed an attractive line of their well-known porcelain specialties.

American Electric Heater Company, Detroit, Mich., was represented by Mr. B. H. Scranton, president, and George J. Schneider, superintendent and electrician. They exhibited a complete line of electric heating apparatus.

Electric Gas Lighting Company, Boston, had a large display of its various products such as bells, annunciators, etc., as well as the long-established Samson batteries. Chas. E. Lee and T. H. Sherman explained the merits of the goods.

John A. Roebling Sons Company.—Visitors to the booth of John A. Roebling Sons Company were cordially greeted by Frank W. Harrington, W. F. Richardson, W. P. Bowman, W. W. Affleck, G. W. Swan, C. B. Cushing and J. W. Brooks.

United Electric Heating Company, Detroit, had an exhibit in charge of Mr. Robert Kuhn and Frank Kuhn. A large line of electrically heated cooking and household utensils, together with appliances for industrial use were on exhibition.

The Westinghouse Electric & Manufacturing Company received visitors in a handsomely decorated booth through Charles F. Medbury, W. C. Armstrong, R. L. Rathbone and C. S. Jennings—the latter of the Sawyer-Man forces in New York.

Osborne Flexible Conduit Company, of New York, was represented by C. E. Corrigan, vice-president and manager, and C. B. Roullet, general sales agent. They had an excellent exhibit and gave away handsome match boxes for souvenirs.

The De Veau Telephone Manufacturing Company showed a line of telephones. Its switchless telephone and the new push button telephone attracted considerable attention. Mr. A. S. De Veau and V. C. Gilpin, sales manager, looked after the interests of the company most pleasantly.

Case Shawmut Company had an elaborate exhibit of some of its specialties which attracted great attention. Mr. Harry P. Moore, of the Boston office, was in attendance and gave away as a souvenir a cigar cutter made in the exact shape, in miniature of the Shawmut fuse.

Carleton-Chase Electric Company, New York, made a most unique and novel exhibit in the form of a miniature reproduction of its entire building in New York. The model, about 6 ft. high, 2½ ft. x 5 ft., was illuminated, and made a very pretty effect. J. A. Vaughan and Percy R. Frost looked after the interests of the company.

The Holtzer-Cabot Electrical Company, of Boston, was represented by Edward R. Harding, western manager, and T. Meimema. They showed among other things automobile and launch lighting and igniting outfits, hotel telephones and motors. A number of the booths at the convention were connected by their new intercommunicating telephone.

Thos. E. Clark Wireless Telephone & Telegraph Company, Detroit, as usual, were a prominent feature of the convention. They had a working exhibit, which attracted a good deal of attention and the interests of the concern were ably looked after by Thos. E. Clark, Gustave F. Riefstahl and Ackland Stiling. The apparatus was operated by Fred F. Garrett.

The Elblight Company's exhibit, as at all conventions, attracted great attention. Its display showed many new features and designs, and Russell Spaulding and E. H. Abadie were assiduous in their attention to all visitors. Mention should be made of their superintendent, J. C. Schaeffer, who was in attendance and looked after the fine Elblight decorations throughout the building.

Fuller Electric Company exhibited one of the very first direct-connected high-speed dynamos ever constructed in the United States. It was built in 1882 by Rodolphus Fuller, present secretary and manager of the Fuller Electric Company, of Detroit, and was installed in Chicago. This dynamo was used in lighting a railroad train by electricity for many years by the Grand Trunk, between Chicago and Port Huron. By its side on the platform stood a machine of the same power and speed built according to the latest plans. Mr. R. Fuller and F. Vollmer were in charge.

Crouse-Hinds Electric Company.—A most elaborate exhibit was made by the Crouse-Hinds Electric Company, of Syracuse, N. Y., lightning flashes radiating from a blaze of light in the booth, the center having a wreath which formed the trade mark of the company. The center of the trade mark contained a Syracuse changeable electric head light, one of the company's many products. Directly above this wreath was the sign "Norbitt" made of changeable monograms. The booth was surrounded by railing, the top of the railing being utilized for exhibiting the Norbitt moulding and conduit receptacle all electrically connected. At the entrances to the booth, of which there were two, were four cut glass aquariums supported on pedestals. In the interior of each aquarium was placed a Norbitt temporary decorative socket with a 16-c.p. lamp. Two of the aquariums contained battery fluid and two water with gold fish, showing the waterproof qualities of the appliances. To the left of the entrance of the booth was the red room, devoted to the display of switchboard and panel boards. The decoration consisted of over 400 ruby lamps, each embedded in a flower-shaped shade, festooned about the walls and ceilings in good taste. Extending the entire length of the exhibit was an enormous electric sign, reading "Crouse-Hinds." The entire equipment consisted of over 1,100 8-c.p. lamps. The various circuits feeding these lamps were controlled from a marble panel enclosed in an oxidized copper-trimmed metal cabinet. Around the walls of the booth were many different designs of panels enclosed in cabinets of oak, maple, mahogany and cherry. Mr. Hawkins, Mr. Norden, Mr. Hills and Mr. Crofoot deserve credit for the fine display they made of their company's product. In keeping with their custom in the past, they distributed a souvenir in the shape of a very handsome leather bill folder for pocket use.

Others Present were C. A. Glack, American Conduit Manufacturing Company; W. C. Osborne and C. D. Goss, Sterling Electric Manufacturing Company; D. B. Scarborough, Vallee Bros. Electric Company; H. W. Cook, John Toler Sons Company; G. L. Crosby, The Cutter Company; H. E. Wronk, W. R. Ostrander Company; G. W. Rodormer, Chicago American Electric Fuse Company; A. S. Hatch, Municipal Lighting Commissioner, Detroit; Prof. W. E. Goldsborough, St. Louis Exposition.

OBITUARY.

J. A. HESSE, who has represented the Fort Wayne Electric Works, in the Southern States during the past four years, died suddenly in Boston while on a business trip to that city recently. Mr. Hesse's headquarters were at Atlanta, Ga., and his work in the Southern district was conspicuously successful.

E. W. BLISS, president of the widely-known manufacturing establishment of E. W. Bliss & Co., died of heart disease on July 21 at his country home in Bay Ridge, Brooklyn. Mr. Bliss was born at Cooperstown, N. Y., in 1836. He served through the civil war, and after the war established the present concern of E. W. Bliss & Co., in Brooklyn. He leaves a widow and one daughter.

THOMAS CHALMERS, one of the founders of the well-known engine building firm of Fraser & Chalmers, died on July 13, at his residence in Chicago. Mr. Chalmers was eighty-eight years old at the time of his death. He leaves a widow and five children, two of the sons being connected with the Allis-Chalmers Company, into which the Fraser & Chalmers firm was merged some time ago with the E. P. Allis Company.

LUTHER STIERINGER, the well-known authority on decorative and park lighting, died on July 17, at Pasadena, Cal., whither he had gone in the hope of restoring broken-down health. He was only fifty-eight years old at the time of his death, but had been in bad health for nearly three years. Mr. Stieringer possessed the extremely rare ability of predetermining lighting effects, and it was this peculiar accomplishment which made the lighting of the exposition grounds at the Louisville, Chicago, Omaha and Buffalo expositions the marvelous successes that they were. Just before his death he was awarded the John Scott medal by the Franklin Institute for his work in this branch of electric lighting, but unfortunately he did not live long enough to actually receive the medal.

PERSONAL.

MR. CALVIN W. RICE has resigned the position of second vice-president and sales manager of the Nernst Lamp Company, of Pittsburg, much to the regret of his business associates in that company.

MR. WILLIAM CURRIE, of the Stanley Electric Manufacturing Company, who for some time past has been at the Pittsfield works as Mr. C. C. Chesney's assistant, has been appointed sales engineer of the Chicago office of the company.

MR. GEORGE H. GIBSON has resigned the management of the advertising and publication department of the B. F. Sturtevant Company, Boston, and accepted a position with the International Steam Pump Company, New York.

MR. J. S. HART, of Hart & Co., manufacturers of Red Cross commutator lubricant, woven wire brushes and self-lubricating carbon brushes, left recently for Europe. Mr. Hart will visit the London, Berlin and Vlissingen offices of the Company, and will establish offices in Paris and St. Petersburg.

MR. T. H. BAILEY WHIPPLE, assistant to the second vice-president of the Sawyer-Man Electric Company, has been elected vice-president and sales manager of the Nernst Lamp Company, succeeding Mr. Rice, whose resignation is noted elsewhere in this column. Mr. Whipple is a man of wide experience and has a long list of strong friends in the electric lighting field.

MR. C. HUDSON MACHEN has been appointed New York sales engineer for the Cutter Company, of Philadelphia, his headquarters being, of course, at 120 Liberty Street, the Cutter Company's New York Office. Mr. Machen is prepared to submit blue-prints and give any engineering information that may be required concerning I-T-E circuit-breakers and Keystone measuring instruments.

MR. A. M. MATTICE, for several years chief engineer of the Westinghouse Electric & Manufacturing Company, has been appointed chief engineer of the Westinghouse Machine Company. Mr. Mattice will act in a consulting capacity for the Westinghouse Electric & Manufacturing Company, but the active duties of his former position will be taken over by Mr. B. G. Lamme, with the title of Acting Chief Engineer.

MR. J. D. MAGUIRE recently resigned the presidency of the Magnet Wire Company, of New York, and joined the staff of the National Electric Company, of Milwaukee (successor to the Christensen Engineering Company), his headquarters being at 135 Broadway, New York. Mr. Maguire informs us that his company has just closed a contract for the entire air-brake equipment for the Intermural Railway of the St. Louis Exposition. The contract was secured under very keen competition and the company naturally feels much gratified at closing it.

TRADE PUBLICATIONS.

INSTALLATION OF CABLES FOR HIGH TENSION WORK. Minerallac Company, Chicago.—This is a most instructive pamphlet, containing general directions for installing high-tension cables and specific illustrated instructions for using minerallac in making splices in such cables.

DIRECT-CURRENT ENGINE-TYPE GENERATORS. Westinghouse Electric & Manufacturing Company.—Revised circular No. 1033, superseding circular No. 1034, and containing an illustrated description of the Westinghouse generator as built for direct driving.

GAS BLOWERS AND EXHAUSTERS. Buffalo Forge Company, Buffalo, N. Y.—A well-executed booklet of pocket size, containing illustrations, tabulated data and descriptive matter relating to gas blowers and exhausters. These machines are built in a large variety of sizes and for every commercial class of service.

HART SWITCHES. The Hart & Hegeman Manufacturing Company, Hartford, Conn.—Catalogue E, containing profusely illustrated descriptions of the various types of electric switch built by this company. The catalogue is finely executed, and the descriptive matter covers the entire Hart line of switches, together with flush plates, boxes, wall cases, and other accessories.

FEED WATER PURIFIERS AND HEATERS, OIL AND STEAM SEPARATORS, ETC. The Hoppes Manufacturing Company, Springfield. Ohio.—This is the 1903 edition of the Hoppes Company's catalogue and is an extremely attractive one. The catalogue contains illustrated descriptions of the well-known Hoppes apparatus and illustrations of incrusted pans taken from Hoppes purifiers. A booklet is also issued, containing in more compact form illustrations and brief descriptions of the Hoppes apparatus.

EQUIPMENT OF A RAILWAY SHOP. Crocker-Wheeler Company, Ampere, N. J.—This is bulletin No. 55, containing a description of the electrical equipment in the new locomotive and car shops of the Lake Shore & Michigan Southern Railway at Collinwood, Ohio. The book is beautifully executed and contains much interesting material. The apparatus was installed on the multiple voltage plan, a triplex motor-balancer being used to maintain the voltages between the two outer and two intermediate wires.

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BUSINESS NEWS.

THE BURT MANUFACTURING COMPANY, Akron, Ohio, recently received its twelfth order from the Baldwin Locomotive Works, for exhaust heads. This order when filled will make a total of 33 Burt exhaust heads in use by the Baldwin works.

A NEW CORRESPONDENCE SCHOOL.—The New Century Correspondence Schools is the title of an institution recently organized at Wilkesbarre, Pa. The prospectus sent out by the new company indicates that the courses are to be very thorough and intelligently handled.

THE ELECTRIC STORAGE BATTERY COMPANY, of Philadelphia, announce a change in address of its New York "Exide" battery depot, which was formerly located at 148 West Eighteenth Street. It will hereafter be operated by the New York Transportation Company, at Forty-ninth Street and Eighth Avenue.

S. MORGAN SMITH COMPANY, York, Pa., has under construction three pairs of turbines, each pair of 15,000 horse-power, for the Hudson River Water Power Company, Glens Falls. The Hudson River Company has already in operation two pairs of Smith turbines of 8,000 horse-power each, so that when the plant is completed it will contain ten units (five pairs) aggregating nearly 50,000 horse-power.

THE ROBBINS & MYERS COMPANY, Springfield, Ohio, has adopted the trade name "Standard" for its direct-current motors and dynamos. This title has long been used by the company as the trade name of its well-known electric fan motors, and is now applied to the larger motors and dynamos which have heretofore been known as the "Protected Type," in order to give these excellent machines a more distinctive name.

ARMOUR INSTITUTE OF TECHNOLOGY, of Chicago, has added to its curriculum a four-year course in fire protection engineering, leading to the degree of Bachelor of Science. This course will be inaugurated at the opening of the college year on September 21, and will be under the direction of Professor Fitzhugh Taylor, formerly engineer of the Underwriters' Laboratories. The requirements for admission are the same as in the case of mechanical, electrical and civil engineering courses.

OTIS ELEVATOR COMPANY, New York, states that the escalator at Twenty-third Street station of the New York Sixth Avenue Elevated Road, which has been shut down recently, has resumed regular operation. The motor which drives this escalator takes current from the street railway system, and it was found that the voltage fluctuations were considerably greater than had been anticipated. The apparatus was shut down, therefore, in order to make the changes necessary to secure better speed regulation at the motor.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, of Chicago and Rochester, N. Y., recently closed contracts for switchboard equipments for the Avena (Ohio) Telephone Company, the Vigilant Telephone Company, Dillonville, Ohio, and the Morrow County Telephone Company, Mount Gilead, Ohio. The Stromberg-Carlson Company also sold recently a special dispatcher's telephone desk to the Interurban Railway & Terminal Company, of Cincinnati.

VARLEY DUPLEX MAGNET COMPANY wishes to call the attention of the trade to the fact that its post office address has been changed to Providence, R. I., this change having been made necessary by reason of the miscarriage of mail addressed to Phillipsdale, the company's mail matter having been sent to Philadelphia in many instances, and in some cases even to the Philippine Islands. The Varley Company has had difficulty enough in keeping up with the orders that have been actually received, and its difficulties have been enormously increased by the miscarriage of orders and inquiries.

THE NERNST LAMP COMPANY, Pittsburg, Pa., reports a rapidly increasing trade in its product. The Pennsylvania Railroad Company is equipping more of its offices with Nernst lamps, some thirty multiple-glower lamps having been installed recently in the freight offices at Broad Street and Washington Avenue, Philadelphia, and the new passenger station at Camden, N. J., having been fully equipped with three-glower and six-glower lamps. The Nernst Company states that in a recent test made at the instance of a consumer in Philadelphia, a 50-c.p. Nernst lamp showed an average consumption of 88 watts, or 1¾ watts per candle.

AMERICAN SCHOOL OF CORRESPONDENCE.—At a series of receptions recently tendered by the management of Armour Institute of Technology to the students of the American School of Correspondence, the well-known correspondent of the Chicago *Record-Herald*, Mr. Wm. E. Curtis, was one of the speakers. Mr. Curtis was so impressed with the earnestness of the 3,000 students who attended, that in the June 29th issue of the *Record-Herald* he devoted his regular daily letter to a description of the work of correspondence schools, President Eliot, of Harvard, while recently visiting the school, expressed himself amazed at the scope, thoroughness and standard of the instruction.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, gave its forty-first annual outing to its employees on Saturday, July 18, at Woodsdale Island Park. Several hundred employees and their families participated in this year's outing, the total number of people present, including the children, being about 2,000. Woodsdale Island Park is about 31 miles from Cincinnati and two special trains of five coaches each were required to transport the guests. A most enjoyable feature of the outing was a series of contests which included a fat man's race, a tug of war, a young lady's race and a three-legged race, of 100 yards each. There was also an extensive dancing programme, thirty numbers being played by an orchestra engaged for the occasion.

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BELTS WON'T SLIP
IF YOU COAT THE PULLEY WITH
WARREN'S PULLEY COVER PUT ON WITH A BRUSH.
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Low Rates. Efficient Service.
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SOLID TRAINS TO NORTHERN MICHIGAN
The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.
All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

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Louis B. Hasbrouck
Nicholas Schloeder
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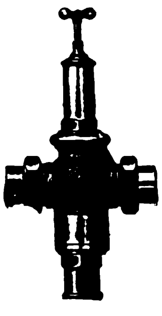

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For automatically reducing and absolutely maintaining an even steam or air pressure.
They are adapted for every need and guaranteed to work perfectly in every instance.
Write for full information and splendid references.
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American Electrician.

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ELECTRICITY IN RAILROAD REPAIR SHOPS.

ELECTRICAL EQUIPMENT OF THE CENTRAL RAILROAD SHOPS AT ELIZABETHPORT, NEW JERSEY.

The Central Railroad of New Jersey has for a number of years maintained a repair shop in a restricted area near the New York water front, which was totally inadequate to its needs. Accordingly, new shops were erected at Elizabethport, N. J., northwest of the Elizabethport railroad station, situated between the Newark Branch and Newark Bay and north of the main line. Part of the site is in meadow and part of it on upland, the upland portion being triangular in form. In laying out the plant, it was planned to get a movement of engines and cars through the shops in a direction parallel with the main line; to so place each shop building that it could be entered from both ends; to so arrange that each shop building could be increased 100 per cent in size without changing the lay-out, and to make the lay-out in each shop such that each department could be distinct and deliver its product as nearly as possible at the point where it was to be used in final assemblage. In applying these conditions to the details of the work, it was found necessary to use a transfer table 80 ft. long and having a travel of 840 ft., including the width of the table. When fully completed the shops will be capable of repairing yearly 450 locomotives, 8000 miscellaneous freight cars and 8000 coal cars in heavy repairs, and 500 passenger cars.

The buildings are entirely of monolithic concrete construction, and constitute probably the largest single grouping of concrete buildings yet assembled. In view of this fact, it might be interesting to review briefly the method of construction. The concrete used in this work was in some cases made of an aggregate of engine cinders, in general with the proportion of one part of cement, three of Edison sand and six of cinders. Gravel concrete was also used, composed of gravel as it came from the bank mixed with sand and unscreened. About one per cent was in cobble-stones two inches in diameter and over, the bal-

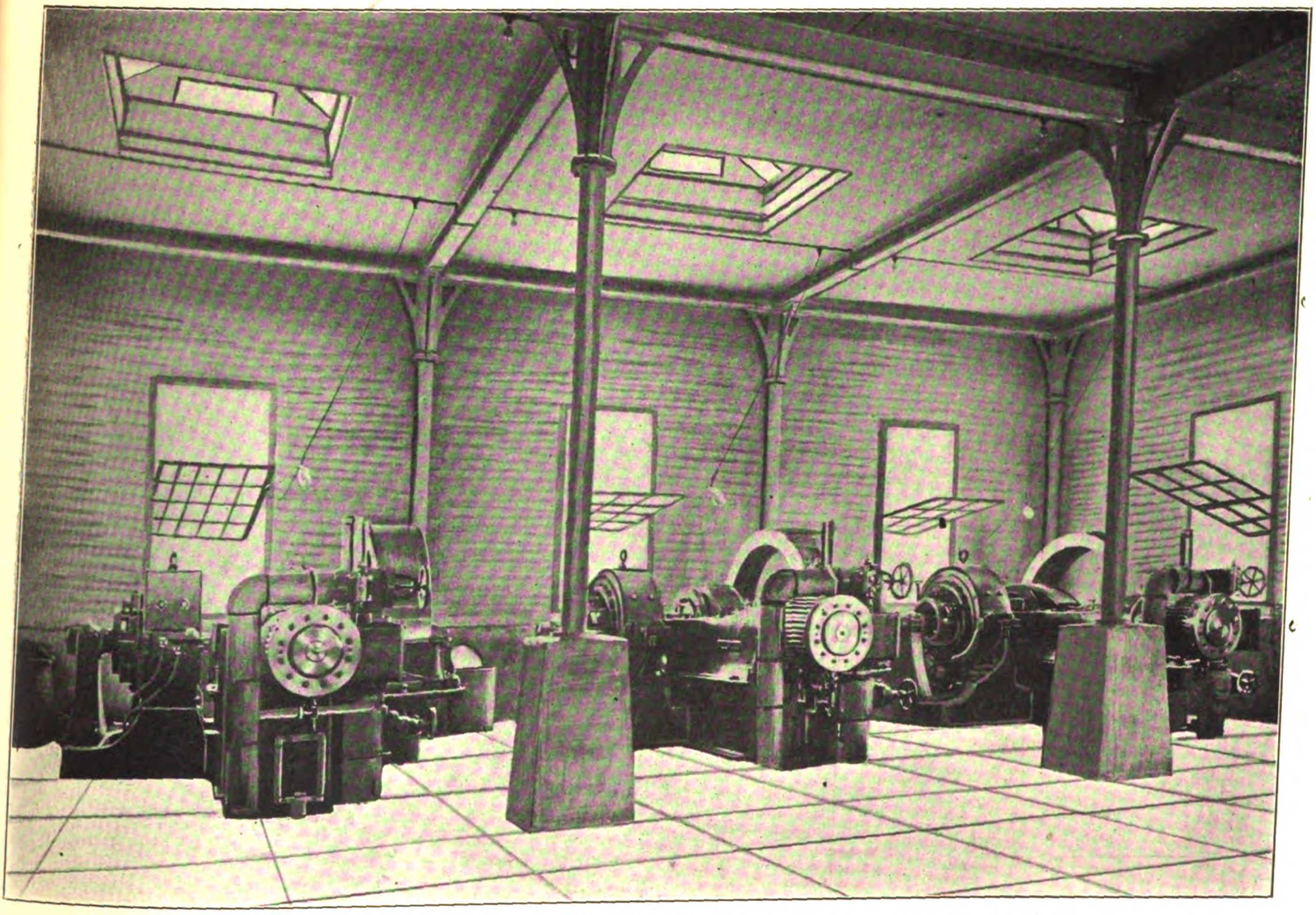

FIG. I.—CORNER OF ENGINE ROOM IN THE ELIZABETHPORT SHOPS OF THE JERSEY CENTRAL RAILROAD.

ance being of different sizes of gravel and sand to the smallest. When this was employed, it was mixed with cement only, the amount of cement used being determined by experiment. In all cases, the concrete was mixed very wet, so that ramming was not required. After being deposited it was puddled with a light wooden rammer to secure an even distribution. No attention was paid to the weather, concrete being mixed and deposited in any weather in which the men would work.

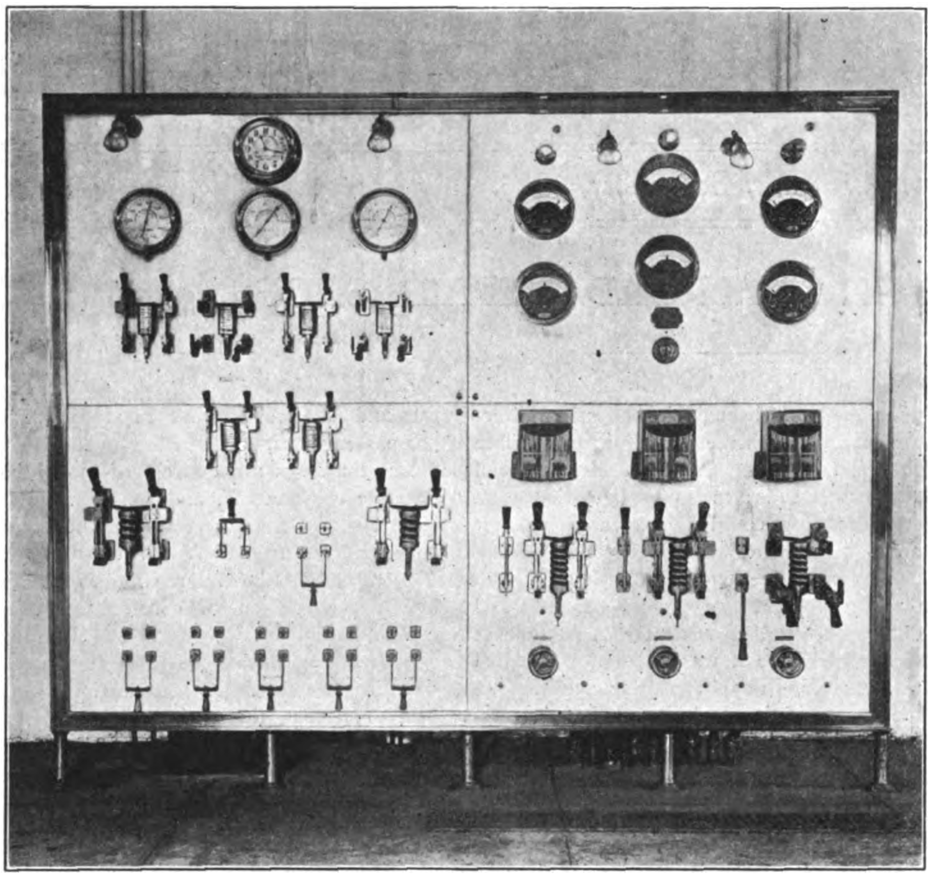

FIG. 2.—SWITCHBOARD.

When the temperature dropped below 25°, all water used was brought nearly to the boiling point and salted, using one pound of salt for 18 gallons of water. At night the work was covered with canvas between the forms and sprinkled with salt. Rough hemlock was used for the forms below ground, and above ground, yellow pine painted with soft soap which gave a smooth surface. No provision was made for expansion and contraction due to temperature changes with cinder concrete, but with gravel concrete a joint was made in every 150 feet. Some of the concrete was mixed by hand and some in mixing machines. Wherever the walls were less than 18 ins. thick it was found that hand mixing was more economical, the labor cost for mixing and depositing the concrete being frequently as low as 50 cents per cubic yard. Where the machines were used, the cost for mixing was reduced, but the cost for handling and depositing was so much increased as to overbalance it.

The power-house, which is situated so as to be the center of the completed plant when it is extended to its ultimate capacity, is an independent building of concrete throughout, divided into engine room, boiler room and coal bunkers. The walls are 12 ins. thick in the basement and 4 ins. above, the basement floor being of concrete laid directly on the ground with a depressed central portion for the pumps. The engine room floor is of concrete and metal, 12 ins. thick and supported on concrete piers so placed as to be in general under the engines and air-compressors which rest directly on the floor. The roof is of concrete, 6 ins. thick, supported by cast-iron columns. The electrical equipment at present consists of three 100-kw. direct-current 230-volt Sprague generators, each direct-connected to a simple Ball & Wood engine running at 250 r.p.m. Space is also provided for two tandem compound generating sets shortly to be installed. All piping, feed-water heaters, water tanks, pumps, and similar apparatus, are in the basement, the piping being supported on pipe stands on the basement floor. The electric conductors are carried on the ceiling of the basement, so that the engine room is entirely free and clear. The engine room also contains two Ingersoll-Sergeant air compressors, each having a capacity of 1000 cu. ft. of free air per minute.

The switchboard, which is of white marble was supplied by F. A. La Roche & Co., New York City. It is arranged in panels, generator panels being separated from the lighting and power distribution panels. Circuit-breakers are provided for all switches carrying 200 amperes or more, and switches carrying less than 200 amperes are provided with Sach's "Noark" fuses. The board is equipped with the usual instruments as may be seen from Fig. 2 The current for both lighting and power purposes is taken from the same bus bars although the lights are fed from separate mains.

The general artificial illumination of the buildings and yards is by enclosed arc lamps of which there are about 300, and the detail illumination is by incandescent lamps, one or more of these latter being placed at each tool. The natural illumination is very good, 36 per cent of the roofs of the machine shop and of the blacksmith shop, and 55 per cent of the paint and repair shops being skylight. This is of translucent fabric giving a uniformly subdued light, making it possible for work to be performed directly beneath it without shading. The walls of all of the buildings are also plentifully provided with large windows.

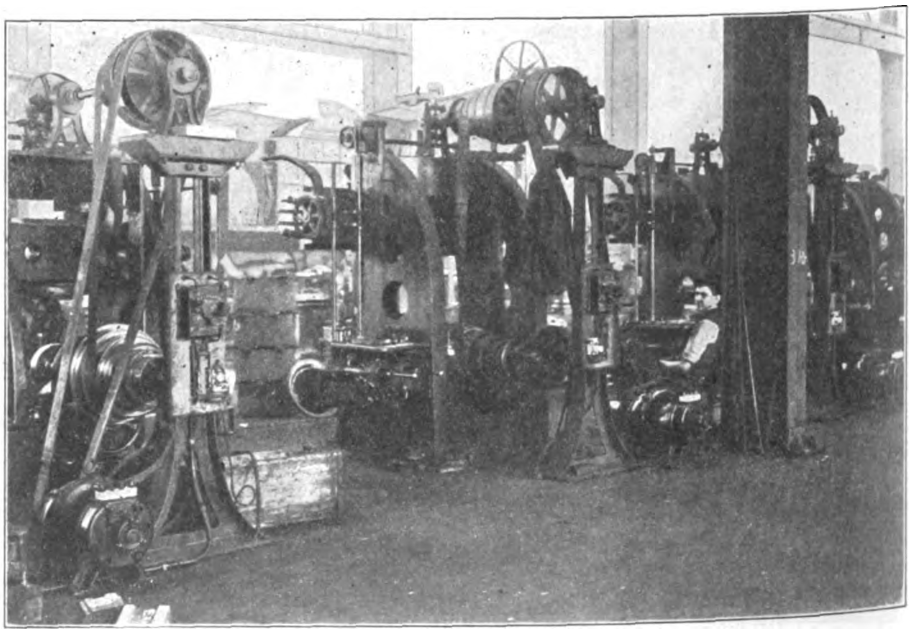

FIG. 3.—GROUP OF INDIVIDUAL MOTOR-DRIVEN MACHINES.

Steam is generated in four 250-h.p. Babcock & Wilcox water-tube boilers, which are at present hand-fired with rice coal, but which will be fitted subsequently with mechanical stokers. A breeching of sheet iron connects the boilers to a 25-ft. stack 5 ft. in diameter, which is sufficient to raise steam when the boilers are cold, and to operate without forced draft all the lighting of the plant, the cranes and the transfer table. For feed water one 10-in. water main and one 8-in. main are brought into the shops from the Elizabethport Water Company's mains at a distance apart of 1200 feet. They are brought together in the basement of the engine room where they are also connected to the fire pumps so that one can be used to supply water to the pumps and the other act as a distribution main throughout the plant for fire service. Pressure on the main under normal conditions is 20 pounds per sq. inch. Each main is provided with meters and swinging check valves, water being distributed from the mains throughout the plant in 4-in. cast-iron piping on the loop system. The water is stored in a tank of 100,000 gallons capacity supplied from the 10-in. city water main, from which tank an independent line is carried to the fire pumps. In addition, a concrete cistern of 600,000 gallons capacity is provided near the power-house, into which all the rain water falling on the roofs of the various buildings drains. This is also connected to the suction side of the fire pumps, giving three independent sources of supply for use in the event of fire, and, of course, as many sources for feed water.

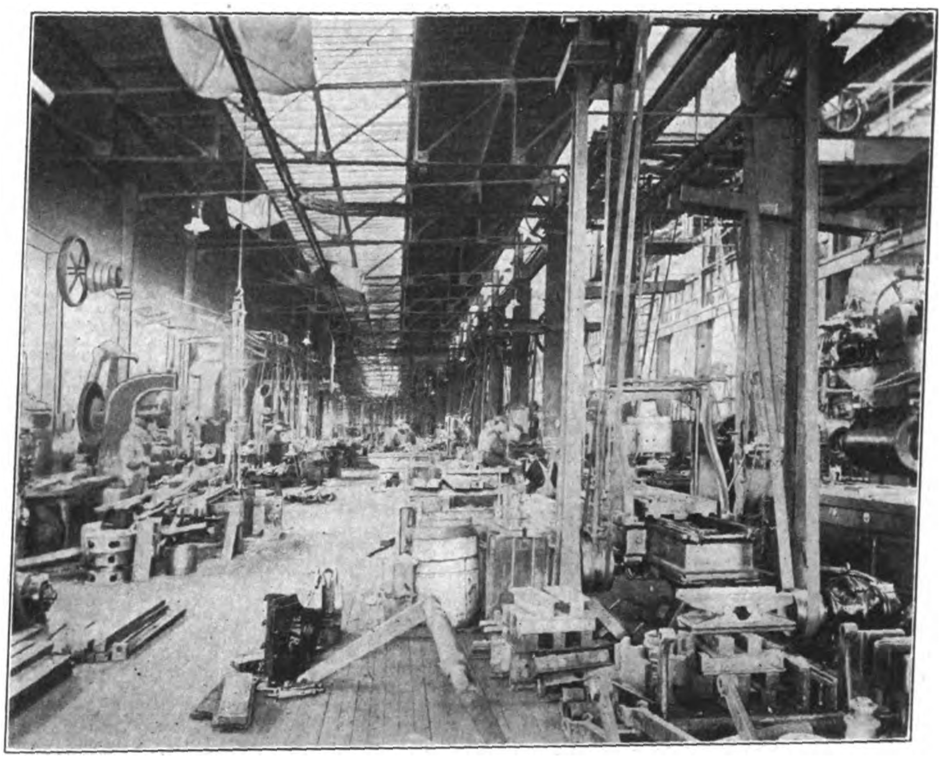

FIG. 5.—VIEW THROUGH ONE OF THE AISLES OF THE MACHINE SHOP.

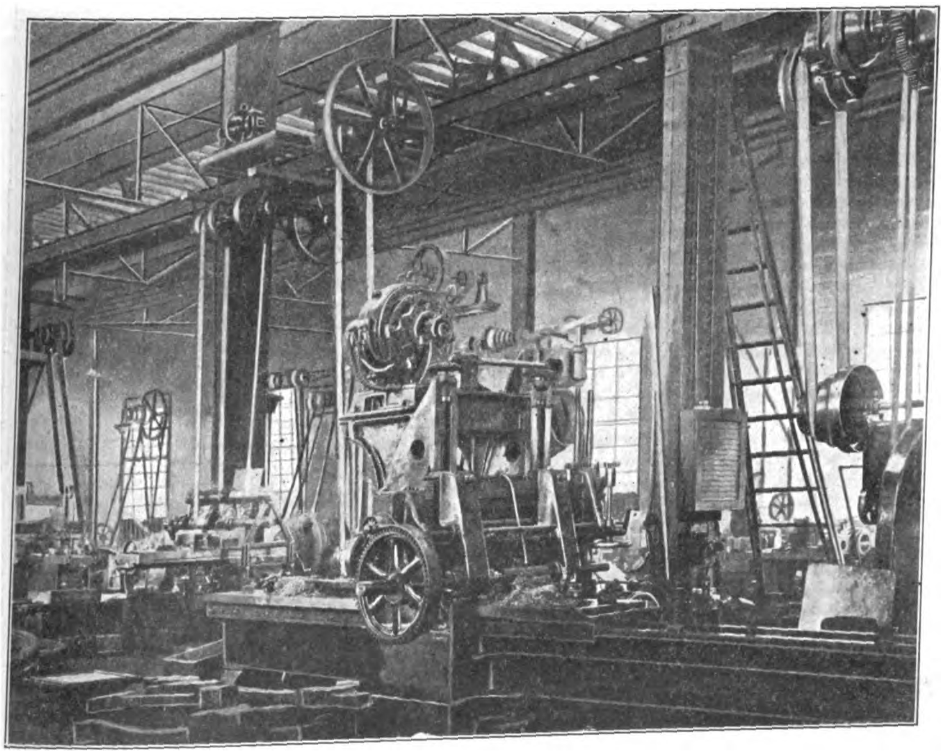

FIG. 4.—A MOTOR-DRIVEN PLANER.

Power is distributed by electric current through concrete tunnels running beneath all of the buildings and connecting them with the power plant, the tunnel being in general 4 ft. wide and 6 ft. high. Special sets of mains are provided for lighting, for operating the motors in connection with the heating system, and for the operation of machine tools in each of the buildings. Compressed air is also conveyed through the tunnels to all of the buildings. Large storage tanks are used in the power-house, and equalizing tanks 4 ft. in diameter and 12 ft. long, at various points in the buildings not more than 200 ft. apart, to equalize pressures, act as reservoirs and permit the use of pipes of moderate size. High-pressure steam is carried through all of the tunnels to supplement the exhaust steam in the heating stacks, to supply steam for testing locomotives, for the operation of steam hammers, and for any other purpose which may subsequently develop. Exhaust steam is led through the tunnels to the heating stacks to utilize the waste heat in the exhaust in the heating of the buildings, and the water of condensation is returned to the boilers by gravity.

The buildings are heated on the hot blast system of the Buffalo Forge Company, the heating stacks being provided for both exhaust and live steam, and fans drawing the air from the building over the stacks and discharging it in general in tunnels built of concrete running the length of the building along the outside wall, with galvanized iron outlets 20 ft. on centers discharging the hot air 10 ft. above the floor in a horizontal direction and toward the ends of the building. In the store house and blacksmith shop heated air is conducted along the roof and discharged at an agle of 30 degrees downward. In the round house heated air is distributed through a tunnel with branches running beside each engine pit and into the pit, there being twelve branches entering the pit. Each one of these branches is provided with a damper which under ordinary circumstances closes the branch. A certain number of outlet nozzles are provided in the form of bends which, when put in place, open the damper in the branch pipes automatically, securing the delivery of all of the hot air against the running gear of the engine. These bends can be rotated so that a very large amount of warm dry air can be discharged under the engine to rapidly free it from ice and to rapidly dry it after cleaning. All of the fans used in the heating system, with two exceptions, are motor-driven.

The machine, erecting and boiler shops are contained under practically one roof, the erecting shop section having a clear span of 70 ft., with 75 ft. under the crane hook. The machine tools are contained in two bays, each of 35-ft. span, north of the erecting shop floor. The electrical conductors for the operation of the various motors are carried in conduits underneath the floor, the panel boards controlling the circuits being placed above the floor on the iron columns. Each of the engine pits has a number of electrical outlets for portable lights, and the center pit has compressed air outlets as well. The machine tools are grouped in departments, each of which is arranged so that the heavier tools shall be under two small cranes and the lighter tools where they can be reached by air lifts. Each department as a whole is so arranged that the piece to be machined passes from tool to tool through the department, traveling first north and then south, so that it leaves the department near the place at which it entered, with the least possible amount of travel, and where it can be delivered by the crane at the place of assemblage.

There are at present in use 110 electric motors having an aggregate capacity of 1013 horse-power, although additional motors are being constantly added. These are distributed as follows:

Blacksmith shop	14 motors
Store and office building	2 motors
Round house	1 motor
Turn table	1 motor
Transfer table	2 motors
Machine shop	73 motors
Cranes	17 motors

The motors, which are nearly all of Sprague make, range in size from ½ horse-power to 30 horse-power, the following table giving the number and size of the various motors in use:

Motors.	Size, h.p.	Horse-power.
5	30	150
11	25	275
10	15	150
17	10	170
7	7½	52½
22	5	110
8	4	32
19	3	57
6	2	12
4	1	4
1	½	½
110		1013

Nearly all of the tools are motor-driven—some of them by motors attached to the frame of the tool and the others by a motor-driven counter-shaft. With the exception of small drills, which are intended to be used as floating tools, being taken to the work by the crane, any tool requiring 3 or more horse-power to operate it is provided with its own motor. Tools requiring less power to operate them are arranged in groups. In the boiler shops oil furnaces are used to heat the plates. Compressed air is used in all of the riveters, the largest being of 16-ft. gap with a capacity of 1¼-in. rivets. This riveter has an electric crane of 40 tons capacity for its exclusive use, which is operated by the riveter foreman who stands on the platform supported by the stake of the riveter, controlling the crane with his right hand and the riveter with the left. Locomotives and tanks are handled in the erecting shops by means of two 50-ton cranes, each having an auxiliary 5-ton hoist, so that when not employed in handling engines they can be used continually for transportation of articles through the shops.

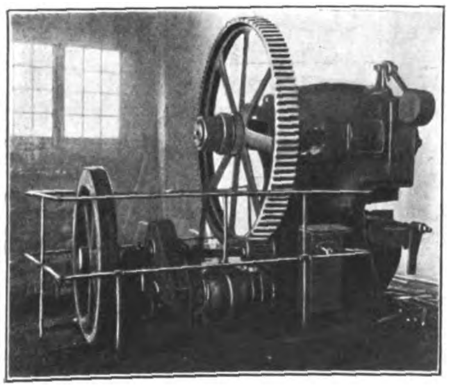

FIG. 6.—MOTOR-DRIVEN SHEAR IN BLACKSMITH SHOP.

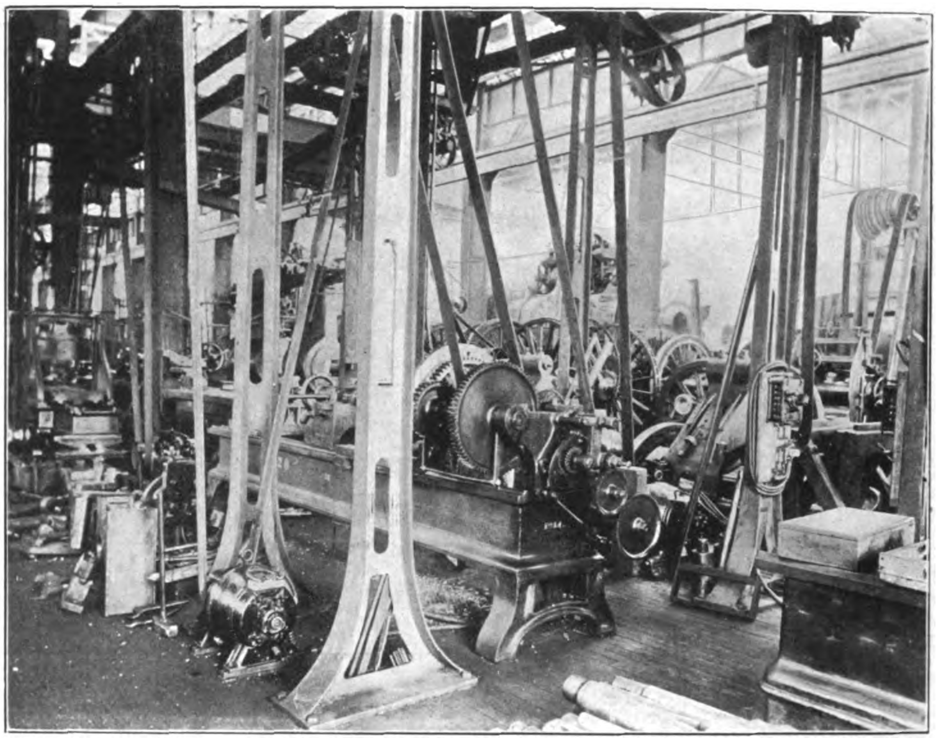

FIG. 7.—EXAMPLES OF GROUP-DRIVEN MACHINES.

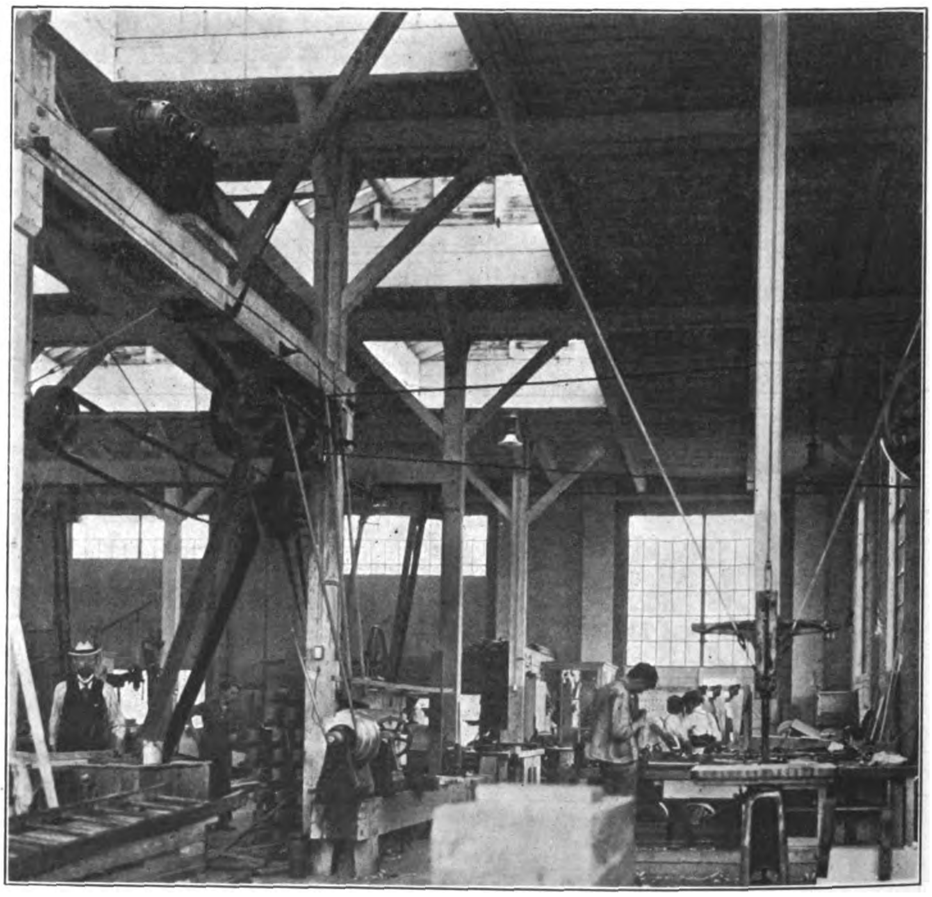

FIG. 8.—A CORNER OF THE CARPENTER SHOP.

The two 50-ton electric cranes in the erecting shop acting in conjunction can carry a locomotive anywhere through the shop.

This is considered an advantage over using one 100-ton crane and is a result of using the longitudinal system of transfer. Where the transverse system is used a 100-ton crane, which usually stands idle about 85 per cent of the time, is necessary and requires structural accompaniments twice as strong as for the longitudinal system. With that, there must be supplementary cranes, run-ways and girders for the lighter regular work. In the longitudinal system the one pair of cranes is in use practically all the time and serves every purpose. The two 50-ton cranes run on one track over the erecting floor, and one 10-ton and one 5-ton crane run over the track in the machine shop bay which contains the heavy tools.

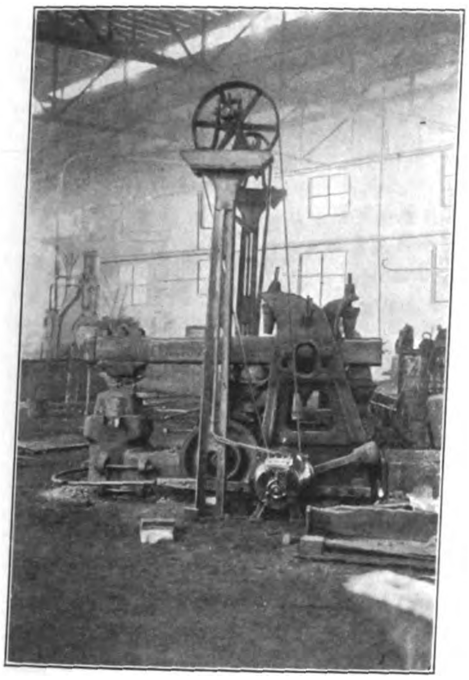

FIG. 9.—MOTOR-DRIVEN HAMMER IN BLACKSMITH SHOP.

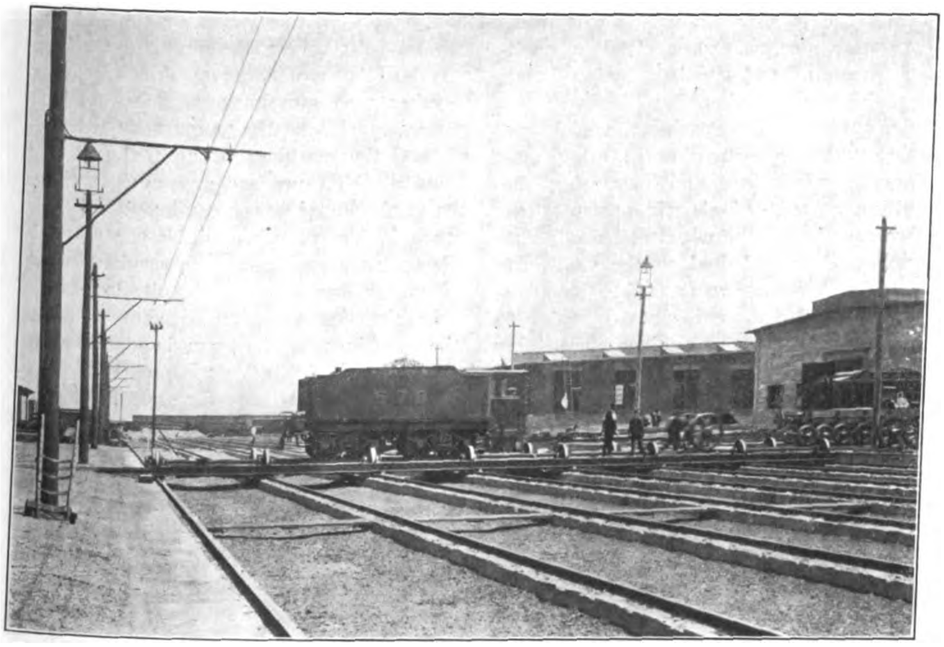

FIG. 10.—DOUBLE TROLLEY MOTOR-DRIVEN TRANSFER TABLE.

The blacksmith shop is furnished with down-draft forges made by the Buffalo Forge Company. Tools not operated by steam are operated by electric motors. The crude oil which is used in the blacksmith shop is contained in a tank in the oil house and is led by a separate line to the shop. An electric circuit runs from the blacksmith shop to the oil house and a controlling device is provided in the oil house by means of which when crude oil is desired in the blacksmith shop a valve is electrically operated in the oil house to permit the flow of the oil. When this valve is released by breaking the circuit the oil flows back again by gravity into the oil house tank. The oil, which can be drawn to any amount up to 60 gallons, is forced to the blacksmith shop by compressed air.

The transfer table has a run of 800 ft. at the rate of 300 ft. per minute. The runways are placed 11 ft. apart on centers, and as shown in Fig. 10 are continuous concrete walls, with broad footings, the walls being 18 ins. thick, the footing 10 ins. thick and 5 ft. wide with metal embedded in the bottom. The outside walls are made particularly heavy to withstand the shock of the engines moving over the joint between the transfer table and the fixed rails. The table itself is of heavy structural steel framing and is operated by means of two direct-current motors with series-parallel control. The same motors are used to operate the hauling device. The entire plant was designed by George Hill, of New York City.

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THE CHOICE OF HIGH TENSION INSULATORS.

BY H. C. KNOWLTON.

However important good material and workmanship may be in regard to the poles, cross arms, tie wires and pins of a high-tension line, it is imperative that the insulators be designed, built, tested and installed with the utmost skill and care, for the integrity of the line depends upon their adaptation to the service furnished. In the choice of insulators for circuits of 25,000 volts and upward, four essential features in design should be given special attention, *viz.*, resistance to puncture; resistance to arcing, to pin or cross-arm; proper distribution of electrostatic strains and low capacity; and proper creepage surface.

The voltage required to puncture an insulator should be enough greater than the voltage required to arc over from wires to pin under any conditions to insure the insulator against injury in case of abnormal voltage. Wet tests, made by spraying a stream of water upon an insulator from a sprinkling hose inclined 30° from the horizontal and 4 or 5 feet away, usually indicate much greater liability to puncture than when the insulator is dry. Experience has shown that the relative mechanical forms of the petticoats exercise a marked influence upon the tendency to puncture. When the petticoats flare widely or are short there is usually less concentration of electrostatic strain on the inner petticoat, and consequently less liability to puncture.

Resistance to arcing is chiefly a function of the longest combined air and insulator surface path which the discharge can be forced to take in passing from the wire to the pin or to the cross-arm. If an insulator be designed to withstand a dry puncture test at double its working voltage, the arcing voltage under the wet test becomes less important as a factor influencing the construction and design. In making tests on high tension insulators their probable behavior under commercial operation must always be kept in mind, and the fascinating results which such experiments afford must not distract the testing engineer from his real purpose, which is to determine which particular insulator is best suited to his operating requirements. Insulators should always be compared under the worst conditions to be expected in practice. Dry tests chiefly indicate the relative static activity of insulators. The possibilities of resonance on the line will largely influence the importance of the arcing voltage. In general, a factor of safety of 3 on arcing voltage in normal operation is not too much to expect. This gives 1½ in case of a breakdown of insulation on one side of the line. The puncture test should be twice the normal line voltage, or 120,000 volts on a 60,000-volt insulator.

In regard to electrostatic strains, the behavior of an insulator in the way of noise and display under test may be taken as an indication of its static capacity and effectiveness of material distribution. The point of visible static discharge should be kept at least as high as the full line voltage, in order that no insulator shall be subjected to undue strain. The area of creepage surface should be made as high as is consistent with reasonable design.

In testing high potential insulators careful notes should be taken of their behavior at all critical points in voltage application. Points to be specially recorded are: the first appearance of visible static discharge from the edges of the insulator under test; the point of first sparking, or discharge from one part to another; the point of general activity—lively and more general sparking snapping and crackling; and point of arcing over from wire to pin—or puncture in case of a faulty insulator. As a general rule these points are well defined.

It is well to realize that questions of price and delivery are not of the first importance in dealing with insulator problems. Probably no single device involved by modern engineering so well illustrates the saying that cheap goods are dear at any price. The selection of insulators for any high-tension line worthy to be placed in commercial operation as an example of the latest and best practice implies careful study of the dsign, conversance with the general methods of manufacture, severe tests under unfavorable conditions, and the best installation which the judicious expenditure of money can accomplish.

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MEASURING THE POWER OF MACHINE TOOLS.

BY GEORGE E. WALSH.

Machine shop methods have changed so materially within the past decade that the mechanic has had to turn electrician to some extent in order to keep abreast of the times. Electrically driven machines and tools are so commonly installed to-day in the large and small shops that possibly surprise would be caused by the absence of electrical power for operating them in any first-class shop. Yet the change has not come about except through mathematical demonstration of the higher efficiency of electrically-driven tools and the elimination of many old troubles and expenses.

The increased output of electric tools is nearly always followed by a corresponding decrease in the cost of operation. Tools and machines that are capable of doubling their output capacity can naturally be made far more economical in operation than those which have no margin of increase in capacity. Consequently in small shops where the output of the tools has a low fixed limit electric motor drive has found less favor than in the larger shops where the output has not reached its limit. Higher speeds and greater cutting capacity must inevitably reduce the cost of manufacturing, and many tools are now built with this in view. With motor drive the limit of cutting speed is measured only by the size and power of the motor.

The belt system of operating tools was always unsatisfactory in shops where high speeds were needed. Besides the delay caused by shifting and adjusting belts, there was always the troublesome difficulty of making the speed shift rapidly from high to low on separate and individual tools. The drive was uncertain and troublesome from many points of view. Yet the belt system is still in use in shops, and it will continue so for some time; there are certain classes of work that can be done satisfactorily with belt drive, but they are becoming more limited in quantity every year.

The construction of enormous modern machine tools introduced a new problem in the work of operation. In the manufacture of huge plates with angles that must be cut with mathematical exactness, and the construction of machinery containing castings so large that giant cranes must be erected to handle them, we have taxed the old method of operating tool machines by countershafts and belts beyond the limit; the electrical drive is the only possible method of handling the new machines satisfactorily. Machine work is becoming every year more difficult and intricate, and yet larger and heavier.

The amount of power used by the different machine tools is determined by each individual shop for its own classes and conditions of work, but within the past few months some statistics have been obtained which will form reliable data for approximate general estimates. In operating machines in groups by motors allowances have to be made for the friction of the shafting and belting. Modern line shafting, however, is made in the best shops so that friction is reduced to a small figure. A two hundred foot line shaft, 2½ inches in diameter, can in many shops be turned by the hands when not belted up. Such a line shaft and its counters can be operated by electric power with about 1.5 horse-power. The actual friction in this way is consequently small, and it does not make an important factor when some twenty-six hangers are adjusted to it, and running a group of machine tools. Thus in the Buffalo, Rochester & Pittsburg Railway shops at Du Bois, Penn., such a line shaft driving a group of nine machines consumed in a fifteen minutes' test a maximum of 10.43 horse-power and a minimum of 0.88, giving an average of 4.6 horse-power. In this group of machines there were small and large ones. The large ones included a heavy wheel press of 50 tons, a 72-inch wheel lathe, an 84-inch Niles boring mill, and a 60-inch planer for cutting cast iron. There were also an emery wheel, a small wheel press, a band-saw belt, and a Pond radial drill in operation.

The question of increasing the load was further tested by throwing in other machines in succession, and measuring the resulting amount of electric power taken. When a 42-inch lathe wheel and an 84-inch boring mill were belted to the shaft, the power on an average was raised to 6.9 horse-power; but this large increase was due to the fact that the two machines were doing work, and the boring and cutting machines consumed nearly as much power in starting up as all the others of the group did when in full operation.

The amount of power consumed in starting up the heavier machines varied in the different tests from a 2 or 3 horse-power up to 15 and more. Thus an 18-inch slotting machine and a 62-inch planer required 15.5 horse-power to start up, but afterward they ran smoothly with 5.2 horse-power.

The testing of single machines is probably more important than that of groups, and the measurements of power more accurate. For instance in operating a planer and slotting machine together with drill presses there is always some difficulty experienced in apportioning the power owing to the constant shifting of the load caused by the reversals of the planer and the slotter. The maximum amount of power used for the reversals brought the average up to a high figure.

In starting up the small tools even the loss first experienced is quite large. A single 40-inch wheel lathe with one tool cutting will, for example, require nearly 5 horse-power, although steady running may later be made on ½ horse-power or a maximum of 0.7. A 79-inch wheel lathe, with two tools taking roughing cuts on a pair of drivers, has frequently been operated on 4 horse-power after it was once well under way.

Modern heavy planers and slotters require as a rule about the maximum of power. A 60-inch planer, while machining a cast-iron cylinder, required at reversal 8.5 horse-power, but in the ordinary running 2 horse-power was sufficient. This constant shifting and variation of the load for running and reversal makes the operation of a planer by electric power far more economical than by any other method. The saving in loss is considerable in the course of a day. Likewise an 18-inch slotter that took 0.03 horse-power for running with tools cutting steel required at reversal 1.2 horse-power. This shows clearly the difficulties in the way of grouping these machines with others to be operated by a line shaft where the speed is more or less constant. Few tools shift the load so rapidly and continuously as these.

In some shops the grouping of machines to be operated by electric power has been so carefully worked out that the maximum shifting of the load of any group is comparatively small. Slotters and planers are grouped together so that the reversals come at certain intervals simultaneously or separately. In this way the load can be regulated according to needs. By the old system of belts where the maximum of reversal of both of these machines grouped together came simultaneously, the available power was frequently temporarily exhausted, and the machines brought almost to a standstill. To prevent any such accident the minimum of power employed had to be much higher than would be consumed in the ordinary running. The resultant waste of energy was steady and quite large.

In the modern machine shop grouping the machines so they can be operated together or singly by electric power is one of the most important factors. Experience has shown that machines which carry about the same load up to a given maximum can best be grouped together, while those which shift the load frequently between wide extremes should be operated either singly or in pairs or groups by themselves. Thus, running emery wheels, drills, presses, boring mills, planers and slotters in a single group would not produce good results either in operation or in cost. Tool grinders, milling machines, drill presses, rod drills, and turret lathes are operated in single groups with excellent efficiency. In fact, a 16-inch lathe, a drill press, and a grinder have frequently been operated together in a group at an expenditure of only 1.9 horse-power. This, too, in the face of the fact that the grinder alone took at starting up nearly double the amount of power required to run the entire group when in motion.

There is a wide variation in tools run by any power, and this must be considered in estimating the measurements of the power needed. While the difference between the starting-up resistance and the running resistance of a tool grinder was nearly 1 to 5, a 20-inch lathe cutting steel shows a ratio of only about 1 to 2; the starting up power required by the lathe was 4.7 horse-power, and the running power 2.5 horse-power.

This sort of study in the power required by electrically-driven machine tools could be carried on indefinitely, and it probably will as new experiments are made. By means of ordinary electrical instruments exact measurements can be made of the amount of power used; but under the old methods the horse-power consumed for operating any group or single machine was largely a matter of guess-work. There is, of course, a certain amount of error that will creep in, but this is so small, or else it can be so readily corrected, that it will not materially alter the conclusions.

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AUTOMATIC BLOCK SIGNALS FOR RAILROADS.

BY RALPH SCOTT.

"Block signals" is a term which is applied to an arrangement of devices, either automatic or manual, which gives warning to an engineer as to the condition of a "block" or section of track; and as to whether he may proceed with caution, or full knowledge that everything is in a condition to allow him to proceed with safety. These blocks or sections generally consist of one mile of track, being shorter where traffic is "bunched," or a large number of crossovers and switches are present; and longer when traffic is least.

These blocks are protected by a disc, blade or revolving member by day, and by colored lights at night, which give warning to an engineer if a switch is open, train in the block, or other dangerous defect is wrong with the block, which he is approaching. A good signal equipment will indicate danger in a block in which there is a broken rail, an open switch, a train or car or handcar on the track, or a defect in the signal apparatus.

Signal systems are divided into two classes, according to the nature of indication, namely, normal clear and normal danger. In the normal clear system the blade, semaphore or disc is normally held at the "clear" or no danger position, continually occupying this position unless the block which the signal protects be occupied or otherwise dangerous. In the normal danger system on the other hand, the signal is normally held at "danger," maintaining this condition until a train approaches the signal, when, providing the block in its rear is clear, it will indicate "clear," and hold this position until the first pair of wheels crosses into the signal's block, when the signal moves back to "danger."

There are a number of ways of indicating a clear, caution or danger condition of a block; these, however, may be divided into three classes, namely, (1) systems of color; (2) systems of position, and (3) systems of motion. For "color" systems, the signal in general use is a colored disc, moving in front of a white surface; the disc moving away from the surface leaves the white area alone visible. In "position" systems, the danger and clear indications are produced by the position of a blade or semaphore; when the blade is horizontal "danger" is indicated; when at an angle, or nearly vertical, "clear" is shown. These semaphores may be colored also, and thus be made to give signals of color. The motion signals consist of a revolving or pivoted member, which indicates to the engineer to keep in motion if the signal member is in motion and stop or proceed with caution if this member be at rest.

By night the above signals have all color indications, with the exception of the revolving or motion signals, which either flash intermittently the rays from a lamp by intercepting them or move the lamp itself.

With disc and semaphore signals the different colors are produced by means of colored glass discs moving before white lights produced by oil or electric lamps. An up-to-date type of oil lamp burns continuously for eight days, and need be attended to but once a week. Formerly, these lamps required attention every night.

Just here it may be said that the disc signal is going out of vogue, the semaphore signal being regarded as standard. This is due to the fact that the glass in front of the moving disc sometimes becomes obscured by snow or sleet, giving the appearance of a "clear" signal when "danger" should be indicated. Semaphores are more familiar to the average engineer; they are used on nearly all mechanical and interlocking signals. The automatic movement of the blade requires somewhat complicated mechanisms and contacts; these have been simplified as far as possible, consistent with correct and reliable operation. The experience of several years has produced a class of apparatus that is remarkable for the ingenious methods of overcoming the obstacles that characterize any railroad system.

The general practice in installing block signals is to divide the railroad into blocks, usually one mile long each; these are shorter, however where traffic and switches are greatest. These block limits are defined by insulating joints in the rails; the entire track is thus composed of sections which are electrically separate from each other. The necessary parts to accomplish this are a fibre rail end 3-16 inch thick and of a shape similar to the cross section of a rail; heavy splice bars of oak, fibre or other insulation, for replacing the ordinary fish plates; insulating bushings, to keep the bolts passing through the splice bars from contact with the rail, and special bolts for keeping the splices in place. The rails between splices are made electrically continuous by the use of bond wires, as it has been found that the contact maintained by the fish plates and rails is not sufficiently good to depend upon. Formerly the bonding was accomplished by drilling holes in the base of the rail, but present practice demands that these be drilled in the web of the rail, the metal being thicker and less affected by the weather, owing to its protected position. The channel pins used are of copper-plated wrought iron. The channel is made to take a No. 8 iron wire. When the channel pin is driven home, the sides of the channel move in and grip the wire with tremendous force. The operation of driving produces a perfectly clean surface, which will remain so as long as the channel pin remains in place.

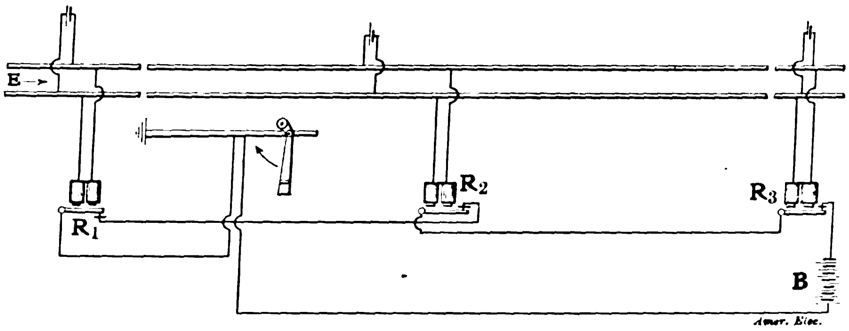


FIG. 1.—SIMPLE SIGNAL CIRCUIT WITH THREE CUT SECTIONS.

Each block is connected to two gravity bluestone cells in multiple, the terminals of the battery being connected to the two track rails. The rails of the block thus have a slight difference of potential between them and it is on this difference of potential that the operation of the signals depend, as will be shown later. Relays having from 6 to 100 ohms resistance are connected across the rails. If the relays be short-circuited by a pair of wheels connected by an axle passing over the rails, it is evident that the armatures of these relays will be released. To provide against the contingency that a pair of wheels at one end may not affect the relay at the other end on account of the resistance of the track between, the blocks are split into a number of separate parts, each insulated from the other, known as "cuts," or cut sections. A slight difference of potential (.7 to 1. volt) is maintained across each section, and a pair of wheels on any section will affect the relay in only that section.

Fig. 1 shows a simple signal circuit having three cut sections. An engine is supposed to be approaching at *E*. This causes the armature of relay, *R*, to drop as shown, thus sending current from battery, *B*, to the signal, providing the armatures of relays, R_2 and R_3 are up, which they will not be if a train be occupying sections connected to R_2 and R_3, or if an open circuit or other defect be in the apparatus, any of the above thus holding the signal at danger.

The battery of a "normal danger" system normally sends no current into the signal; in the "normal clear" system the battery is normally discharging its full current. The "normal danger" system, on account of its cheapness of operation, reliability and almost entire elimination of false indications, has found greatest favor in practice, with both disc and semaphore signals.

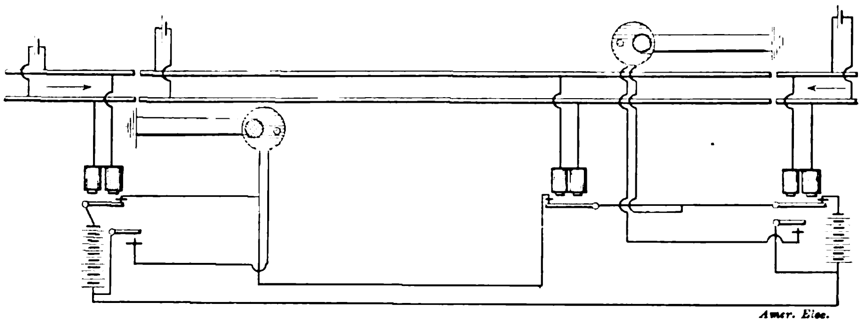


FIG. 2.—DIAGRAM OF CONNECTIONS WITH SIGNALS NORMALLY AT "DANGER."

Fig. 2 shows a simple two-signal circuit on single track, in which the trains run in opposite directions, that is, overlap, on the normal danger system, and Fig. 3 shows the corresponding "normal clear" system. The number of cut sections is the same, a single block being chosen. It will be noted that the same number of relays, track batteries, etc., in each are used, but the "normal danger" system requires only two line wires, while the "normal clear" system requires three. When the block is of great length this becomes a serious item. In the "normal clear" system, it will be noticed, with all relays receiving current the battery is on closed circuit, that is, "holding" the signal at clear, the full battery current passing through the signal magnet or motor mechanism, or sufficient to hold the signal's moving element at the clear position. The "normal danger" system, on the other hand, is, under the same conditions, discharging no current whatever, the batteries being connected in opposition. A passing train, however, will cause the battery to discharge current into the signal (if the relays in the sections ahead have their armatures up), thus causing it to indicate "clear" until the train has just passed the signal, when it moves to "danger" and remains so. The "normal clear" signal does not move until the train has passed it, moving to "clear" again as soon as the train is out of the block. The only change in the condition of the "normal clear" signal, therefore, is when a train is *in* its block; with the "normal danger" system, the only change in conditions is when a train is *before* the signal, and everything is in the right condition to warrant its moving on.

If in the "normal danger" system the line wires become crossed the signal will be held at "danger," no matter what the condition of the track, while in the "normal clear" the same accident would hold the signal at "clear." Where the distances between poles is great, and the line wires bare, which they generally are, this condition may readily occur, and may result, in the "normal clear" system, in holding a signal at "clear" with a train in its block.

In "normal clear" systems, the switch indicators (which are in reality, miniature disc signals placed on small poles or pipes about four feet above ground for the purpose of notifying the engineer of a shifting engine or freight train, of the approach of a through train, and warning him not to shift or cross into the main track) are connected in such a manner to the circuit that the indicators will stand at "clear," that is, have battery current (from a signal main) passing through them, when the signals governing the block in which the indicators are placed, are at "clear;" while in the "normal danger" system, the switch indicators cannot show "clear" when the main line signals do. This is a great advantage in favor of the "normal danger" system, for it enables a brakeman to know that he cannot proceed from a siding into the main line, with his indicator at danger; for he knows that a train must be approaching his block; while even if he should proceed, the main line signal will be held at danger. In signals having protection for both "home" and "distant" blocks, the switch indicators will show "danger" when a train is on the main line in the second block in the rear of the indicator; and in case the switch is opened, the distant signal (from the indicator) will show "caution." By "home" is meant the first block in front of a train, "distant" meaning the second block in front.

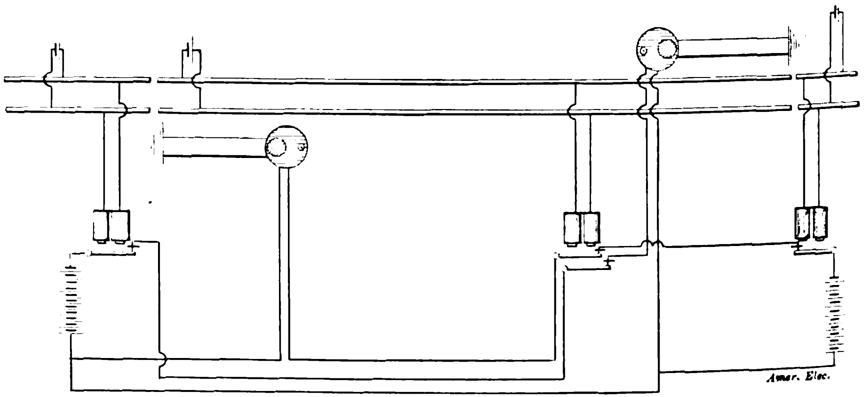


FIG. 3.—DIAGRAM OF CONNECTIONS WITH SIGNALS NORMALLY AT "CLEAR."

Just here it may be said that most railroads having signal equipment immediately discharge a brakeman found guilty of passing from a siding into the main line with his indicator at "danger."

Each signal has its own main battery; the number of cells in each main battery varying, of course, with the length of the circuit over which they operate. They vary in number from 8 to 60. The cells used are of either the gravity bluestone, Gordon or Edison-Lalande type. The disadvantages of the gravity cell are the constant attention required, its high internal resistance and the short intervals between renewing. The Gordon sodium-hydrate battery and the Edison-Lalande potassium-hydrate battery, on the other hand, have low internal resistance, constancy of operation, great capacity, and very long life. Their disadvantages are the caustic nature of their exciting liquids; high cost of renewing, low voltage, and the relative suddenness with which they give out without any warning. However, taking everything together, these latter cells are not more than one-third as expensive to maintain, with the same results as the bluestone cell.

The signal mains are either placed in a small cellar, built of wood, the cells being arranged in tiers on shelves placed around the walls of the cellar; or else they are placed in a small house, resembling a coop, the walls of which are filled with some non-conducting material for the maintenance of an even temperature the year round. These coops and cellars are made sufficiently spacious for the storage of signal supplies and for the protection of the signal men under bad conditions of weather.

The track batteries are placed in a wooden cage one above the other (there being two cells in each cage), and the cage is let down into a cast or wrought iron chute of about a foot internal diameter. This chute is some eight or ten feet long, and is set vertically in the ground, about a foot of its length projecting above ground; it is provided with a cast-iron cover locked in place. Some track batteries have been housed in small wooden boxes, but these have not been found to be able to withstand weather effects long.

The reason for connecting the two cells in multiple is to give long life with small current output for each cell, and also to guard against trouble from open circuits in the connections of the cells. The zincs used in these cells are of the standard Western Union type, weighing four pounds each when new. The jars used are either glass or porcelain; the disadvantage of the first is its liability to breakage; that of the latter is opaqueness, making it difficult to inspect the elements.

The method of maintenance is as follows: every two weeks the batteryman goes over his territory, which on a double-track railroad is from fifteen to twenty-five miles long, according to traffic conditions, the number of track batteries, and number of signals. Alternately, in going over the territory he will "patch" and "renew." Thus, if at a certain time, he is "patching," on the next trip he will "renew." Patching consists in cleaning the zinc, and replacing a quart (in each cell) of the old battery solution with a quart of clean water. Renewing consists in adding new bluestone to the cell, emptying out the old solution, with the exception of a small amount, to furnish the initial sulphuric acid, refilling the cell with clean water, and cleaning the copper element of the deposited copper. The batteryman at the same time inspects the bond wires, track relays and signal mains. As neither renewing nor patching takes up a full two weeks, his available time is spent in renewing signal mains.

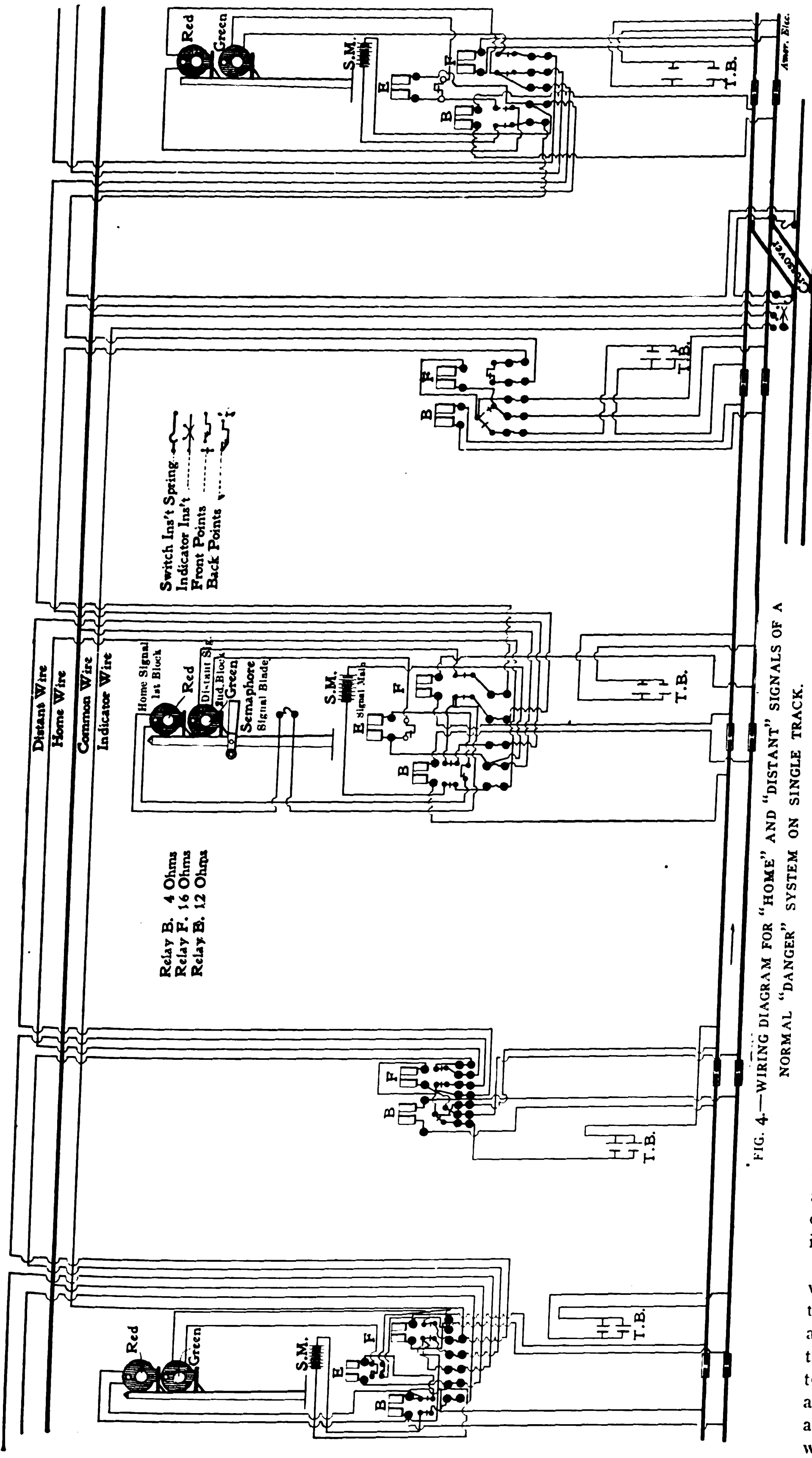


FIG. 4.—WIRING DIAGRAM FOR "HOME" AND "DISTANT" SIGNALS OF A NORMAL "DANGER" SYSTEM ON SINGLE TRACK.

With the battery man is a signalman, whose duty is to keep everything in full working condition; whenever a signal gives a false "clear" or "danger" indication he must take the first train or engine which will pass this signal, and correct immediately, if possible, the false indications.

Fig. 4 shows the wiring plan for the "home" and "distant" signals of a "normal danger" system on single track. Two blocks and part of a third are shown, the blocks having two cut sections each. In one of the cut sections, a crossover is shown, with the wiring for the switch indicator and switch instruments. It will be noticed that the switch instruments of both switches are in series with the "home" line wire, which is the best practice, and will hold the first block home signal at danger. (The direction of the moving trains is shown by the arrow between the tracks.) In this diagram a semaphore (mechanical) is shown. This is operated by a tower attendant, and in the position shown will "hold" an approaching train not only by its own position but also by opening the circuit of the home signal. This is accomplished by using a "commutator," which opens and closes the circuit by the action of a roller upon a peculiarly-shaped copper strip.

Indicators, not shown in the diagram, are also placed at stations and interlocking towers, producing a warning by their indication and by the ringing of a bell connected in multiple with them. These indicators are similar to switch indicators, and are connected in series with the "indicator" line wire.

The signal main batteries are placed in a small cellar at each signal, the relay box being fastened to the side of the signal pole. These relay boxes are weatherporoof, being fitted with a double set of doors to exclude moisture. Each wire entering a relay box is protected by a three-ampere fuse and a lightning arrester, the arrester, fuse and terminal posts forming a "unit"; from 2 to 20 units are used in each relay box. Every cut section requires a *B* and *F* relay; and each signal cut section a *B* relay, an *F* relay and an *E* relay. These relays are very carefully made, and are models of perfect construction. The contact fingers or prongs are fitted either with silver, carbon-silver or platinum contacts, the carbon-silver having proven most satisfactory.

Interlocking devices connected in series with the indicator wire, and not shown in the figure, are placed at switches located at the bottom of a grade, or on a single track. Upon a through or other train entering the second block in the rear of such a switch, the switch becomes locked, by the action of a magnet upon a trip engaging with the switch lever, which (in the "normal danger" system) drops down, at the approach of a train in the same manner as the indicator banner, thus preventing a freight or shifting engine from entering the main line from a siding or crossover. These

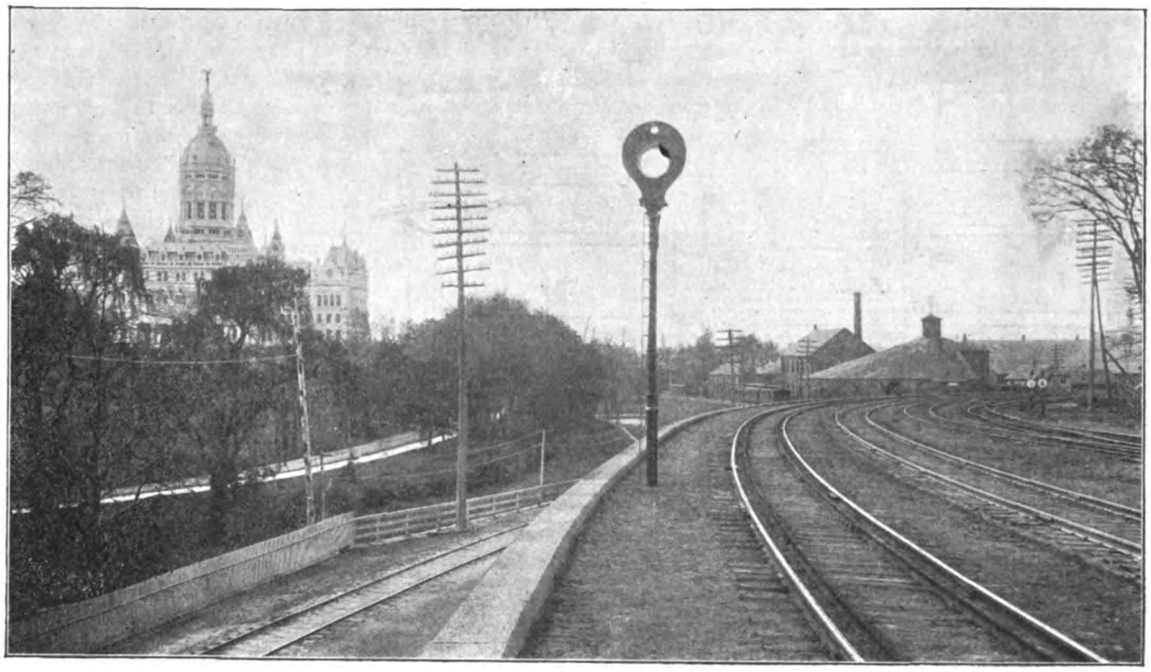


FIG. 5.—NORMAL DANGER SIGNAL ON NEW YORK CENTRAL RAILROAD AT ALBANY, N. Y.

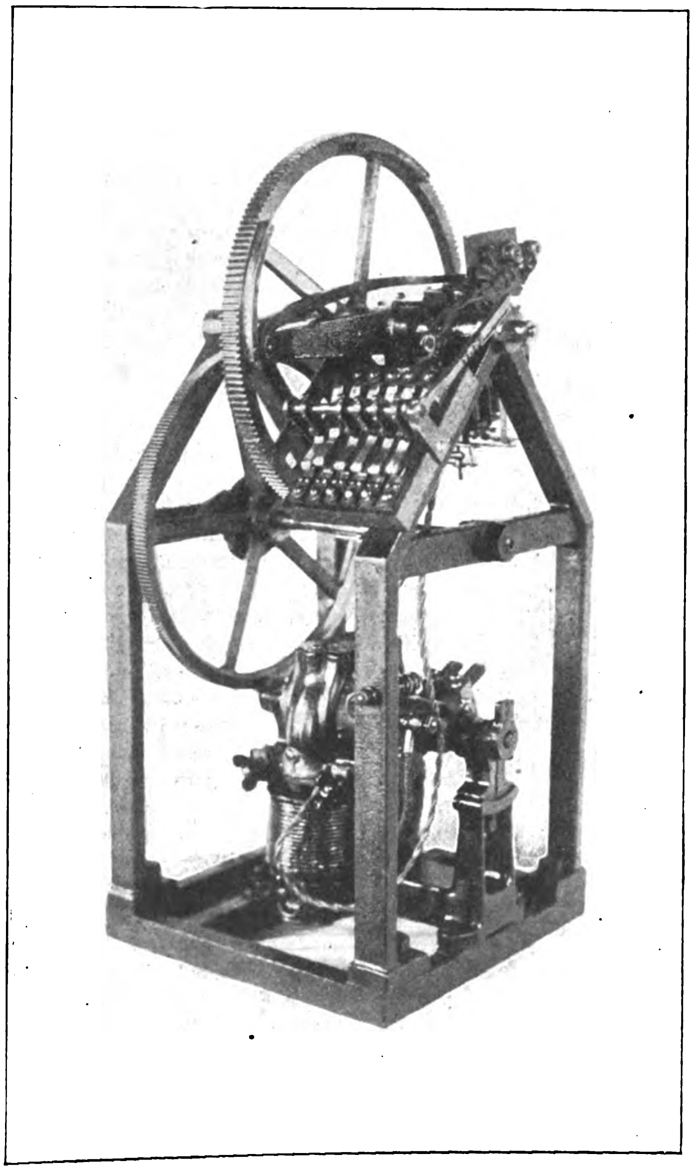


FIG. 7.—MOTOR MECHANISM FOR SINGLE BLADE SEMAPHORE SIGNAL.

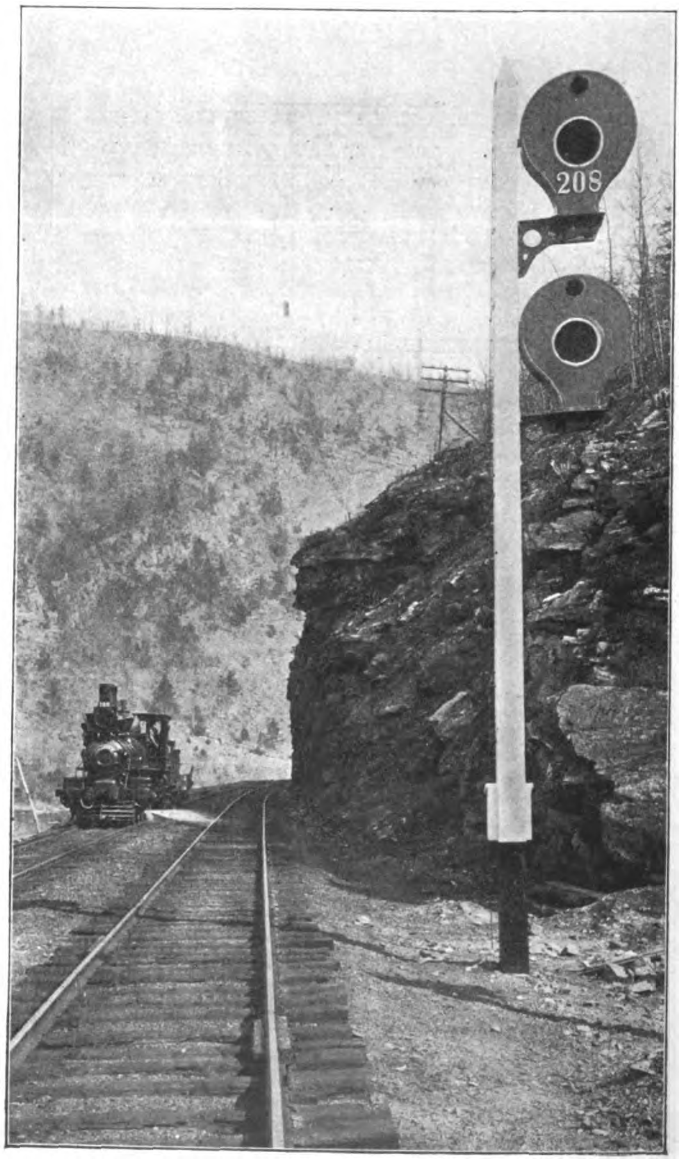


FIG. 8.—TYPE OF SIGNAL USED ON LEHIGH VALLEY RAILROAD FROM JERSEY CITY TO SAYRE, N. Y.

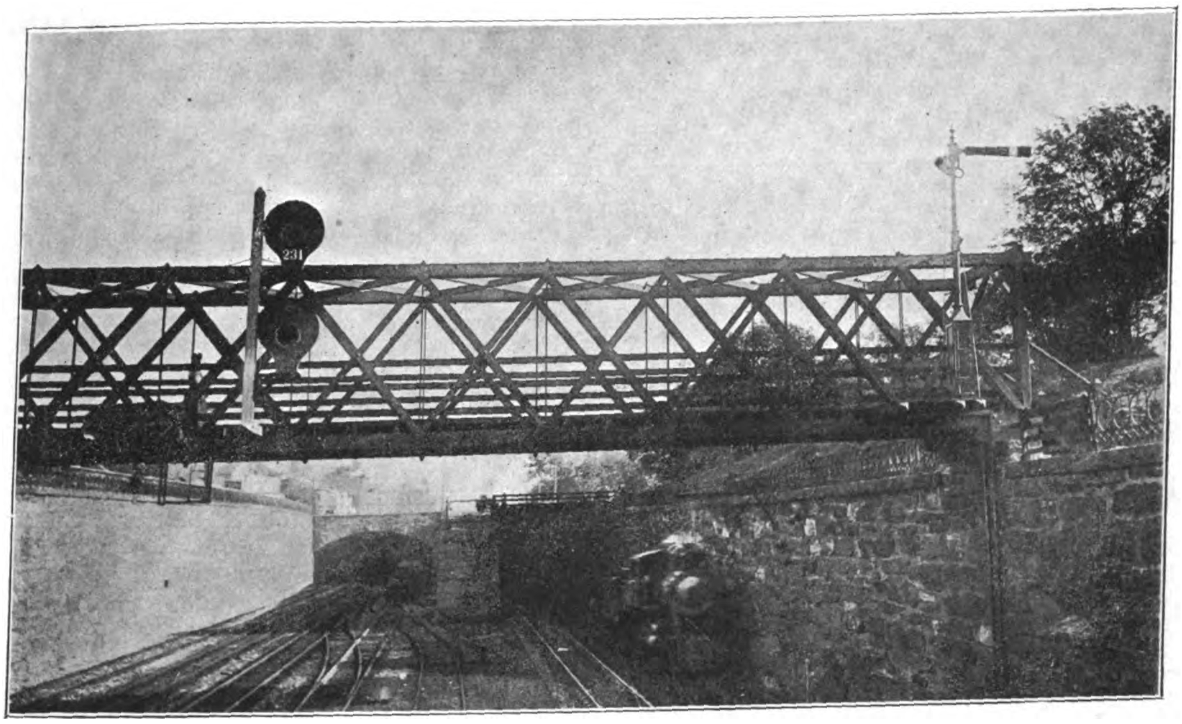


FIG. 6.—SEMAPHORE AND DISC SIGNALS ON PHILADELPHIA SUBWAY.

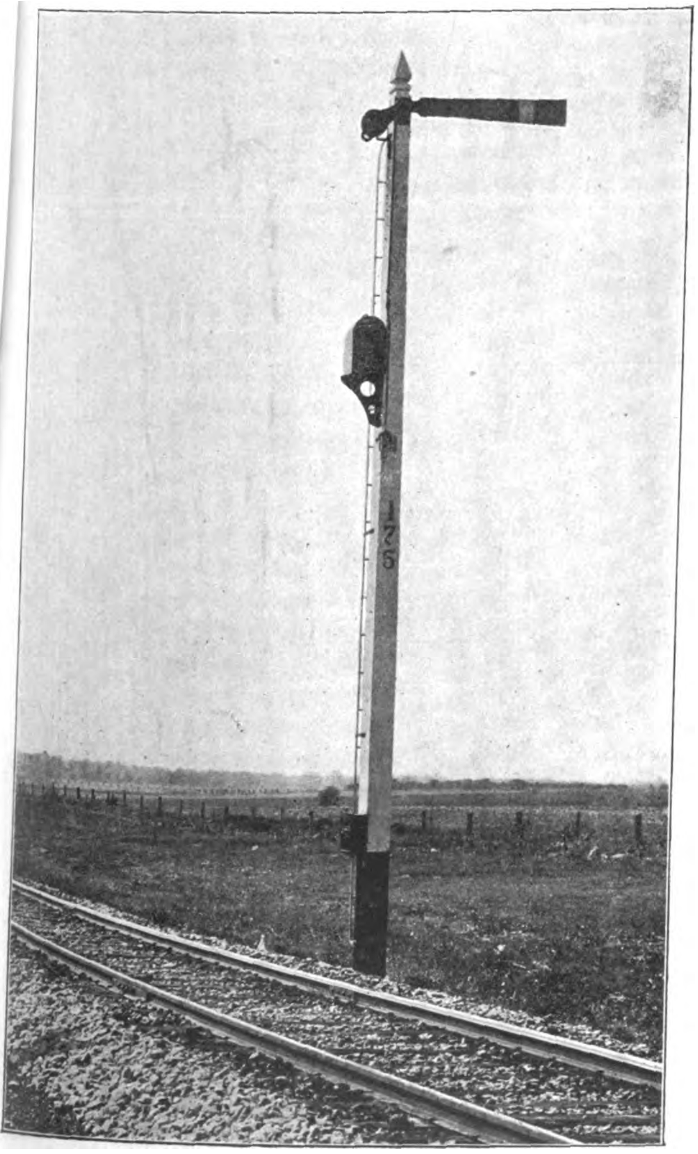


FIG. 9.—NORMAL DANGER SEMAPHORE SIGNAL ON ILLINOIS CENTRAL RAILROAD.

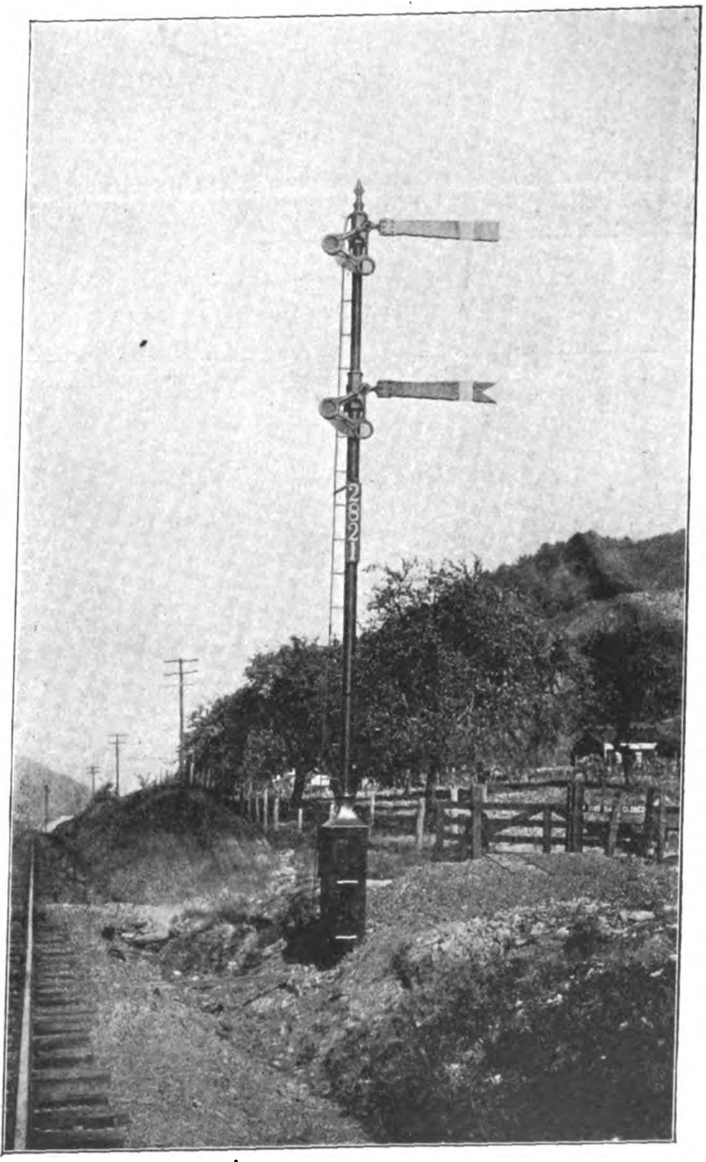


FIG. 12.—STANDARD SIGNAL ON LEHIGH VALLEY RAILROAD BETWEEN SAYRE AND BUFFALO, N. Y.

devices are becoming more and more favored every year, due to the fact that they *prevent* a trainman or brakeman from disobeying his switch indicator. The track batteries are marked *TB*, and are connected to the rails either directly or in series with an *F* relay, both wires being in series with a finger or "back" point which gives current to the relay when the armature to which these points are connected is down, by the action of a pair of wheels short-circuiting the *B* relay, to which the latter armature is connected. Upon the *F* relay receiving current, its armature is lifted up, and makes contact with a finger or stationary piece, and, providing all the *B* relays in the block ahead are receiving current (and consequently have their armatures up), causes current to be sent through the home signal, thus moving it to "clear."

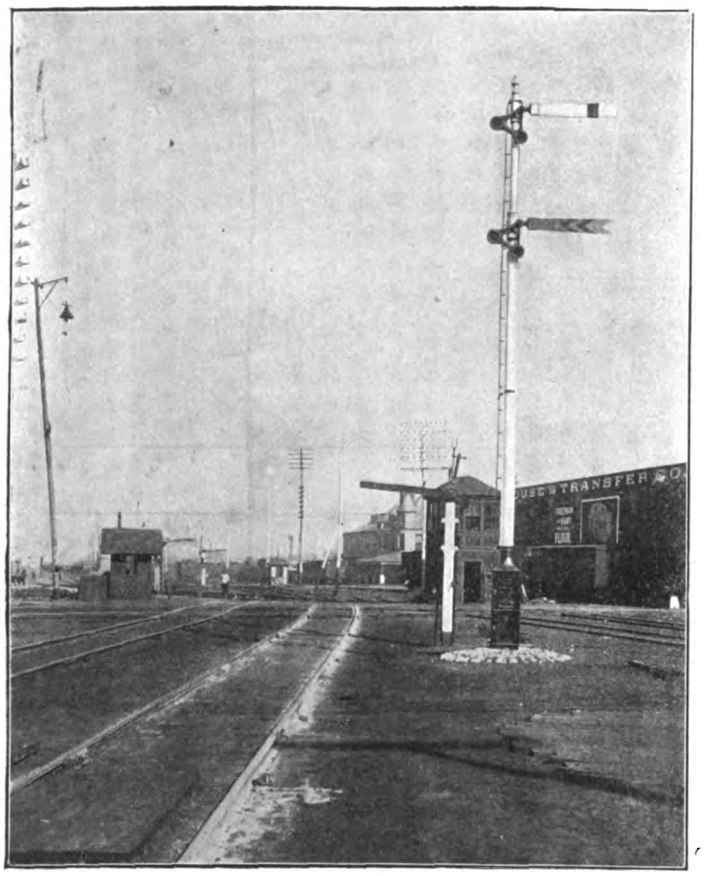


FIG. 10.—DOUBLE SEMAPHORE SIGNAL ON CHICAGO AND ALTON RAILROAD AT THE CHICAGO YARDS.

The "common" wire, it will be noticed, is connected to one side of each signal main, also to one side of each indicator instrument. This not only saves a great number of extra circuit wires but greatly simplifies the system. The disadvantage of this method, however, is the great liability of causing peculiar indications by defective insulation, crosses and grounds. Great care is observed, of course, to secure good insulation. All similar binding posts on relays are put in similar positions, thus lessening the liability of mixing up the circuit wires.

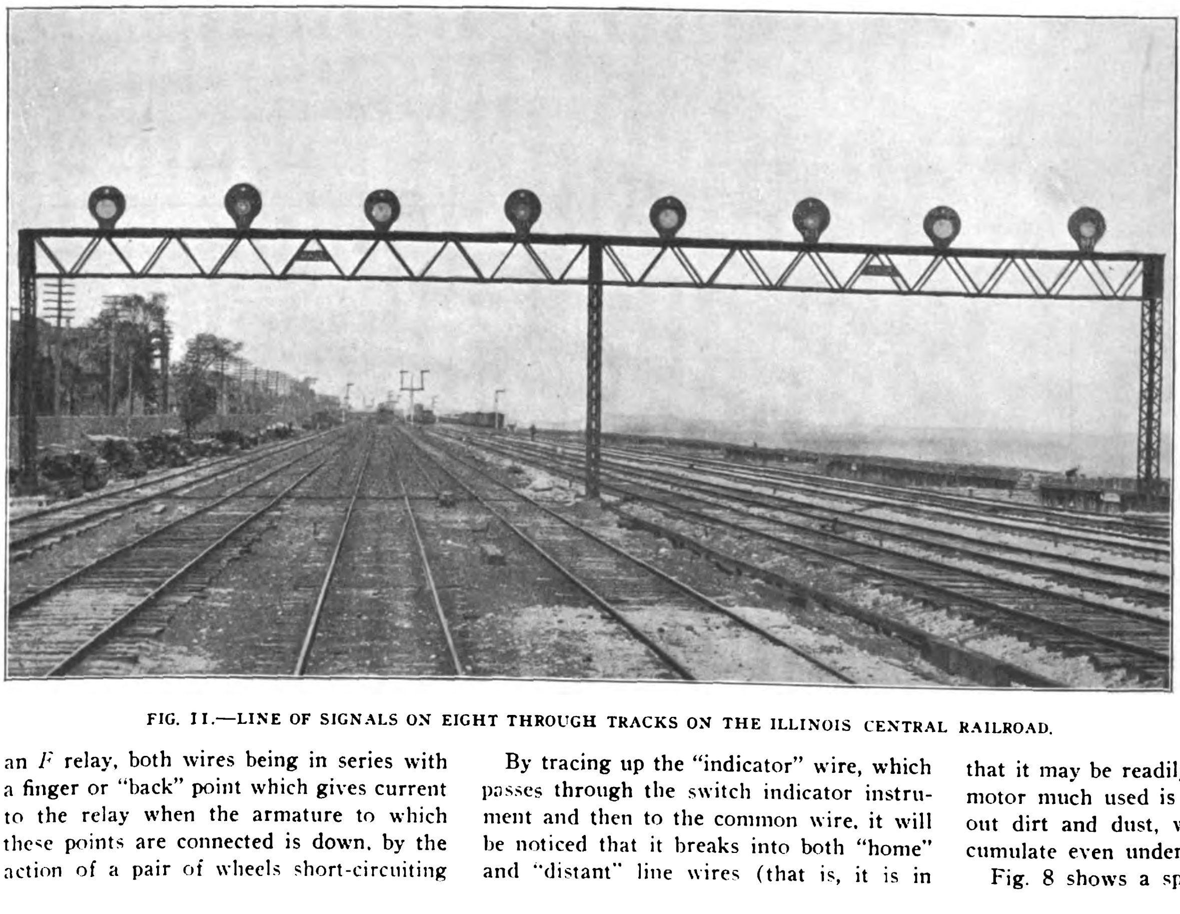


FIG. 11.—LINE OF SIGNALS ON EIGHT THROUGH TRACKS ON THE ILLINOIS CENTRAL RAILROAD.

By tracing up the "indicator" wire, which passes through the switch indicator instrument and then to the common wire, it will be noticed that it breaks into both "home" and "distant" line wires (that is, it is in series with them) passing in series through the fingers of the armatures of the *E* and *F* relays. Thus when either "home" or "distant" signals are at "clear," the indicator instrument will be at "danger," by having its circuit opened. Also when the "home" and "distant" signals are normally at "danger," that is, with no train approaching, the indicator will be at "clear," for it receives its current in series with the armature contacts, which will be held up, so long as no train is approaching and nothing is wrong with the apparatus.

It will also be noticed that each danger signal, which is the upper disc on the signal pole, gets its current (in series with relays and switch instruments) from the battery located at the signal in its rear. The green or caution signal receives its current from the second block in its rear, in series with all apparatus in that block. This order is maintained along the entire system, and enables a signal man to determine quickly whether the battery for a certain signal is in good condition.

The "home" and "distant" line wires, it will be seen, break at each cut section, the points of the relays at these cuts being in series with these line wires.

This "normal danger" system may be changed into a "normal clear" system by having the contact fingers of the *F* relays reversed, that is so that the current will normally flow through the magnets of the signals, holding the signals continually at "clear" until a train or open switch is in the blocks of the signals.

Fig. 5 shows a normal danger signal (disc) used on the N. Y. C. & H. R. R. R. at the entrance to Albany, N. Y. This type of signal has been much used on various American railroads for the protection of single blocks, but at the present time is giving way to the standard semaphore signal.

Fig. 6 shows the signals, which are both semaphore and disc, used at the Philadelphia subway; these give to the engineer a feeling of safety in entering the tunnel which can be appreciated only by the engineer himself. Fig. 7 illustrates the motor mechanism for a single blade semaphore signal, showing the motor contacts and reducing gear. It will be noticed that everything is open, so that it may be readily inspected. A type of motor much used is glass enclosed to keep out dirt and dust, which are liable to accumulate even under the best conditions.

Fig. 8 shows a special type of signal in use on the Lehigh Valley Railroad from Jersey City to Sayre, N. Y. This represents a signal on the Lehigh River at Rockport, Pa. Fig. 9 shows a form of "normal danger" semaphore signal, used on the Illinois Central Railroad. The motor for operating the signal is enclosed in the upper box attached to the pole. The lower box contains the track relays and contacts. The signal is shown in the "danger" position; on the approach of a train the semaphore will move to a half vertical position, thus indicating "clear." Fig. 10 shows a double semaphore signal on the Chicago and Alton Railroad, at the Chicago yard. This gives an example of the complete protection afforded in a crowded district where lines intersect. Fig. 11 shows a signal bridge, or line of signals protecting eight through tracks on the Illinois Central Railroad in the Chicago yard of that road. Fig. 12 shows the standard Lehigh Valley signal in use on that road from Sayre, N. Y., to Buffalo. This is a type of signal which is rapidly replacing all other forms, it having been found most satisfactory under most adverse conditions of weather and traffic.

Railroads require that a good system of signals should never indicate "clear" when "danger" should be shown, a danger signal where "clear" should be shown being considered comparatively unimportant. The causes of "clear" signals when "danger" should be indicated are unbalanced banners or semaphores; relay contacts being stuck or fused; failure of relays to operate, either by residual magnetism or foreign currents, such as occur in the vicinity of street railways; defective insulation of line or track wires, and the breaking of spectacles and banners or blades.

Long railroad experience has shown that the "normal clear" system is much more liable to false clear indications than the "normal danger," especially due to residual magnetism. Moreover, records show that on a main line having trains running every ten minutes the passage of these trains keeps the signals in operation an average of 4 hours out of the 24 in "normal danger" systems, and 20 hours out of the 24 in "normal clear" systems. This shows the relatively greater demand on the signal battery in "normal clear" systems.

American railroads, in general, show a decided preference for the "normal danger" systems, on account of their great reliability under all conditions, the only causes of their indicating false "clear" indications being mechanical, and these being readily eliminated by a proper care on the part of the signal men and maintainer; while in the "normal clear" systems nearly all causes of false "clear" indications are electrical, and are generally hard to discover, this discovery being usually made when it is too late—that is, after a wreck or accident has taken place.

THE MUNICIPAL LIGHTING PLANT AT TALLAHASSEE, FLA.

BY L. A. POOLE.

A diminutive but nevertheless interesting municipal electric lighting plant has been in successful operation for some time at Tallahassee, Fla., the power, of course, being used merely for street lighting purposes. The generating plant is situated at one corner of the town on the line of the railroad, the boiler room being about 30 feet distant from the siding.

The building is a frame structure 100 ft. by 30 ft. over all, and 16 ft. from foundation to eaves. The engine room, 55 ft. by 30 ft., is separated from the fire room by a brick wall with standard fire door. In the boiler room are two 150-h.p., 72-in. by 18-in. Walsh & Wiedner return tubular boilers, set separately in 24-in. walls, with a 3-ft. alley between them. These boilers are equipped with Reliance high and low-water alarm gauges. The breeching connects both boilers to a 60-ft. by 48-in. stack, half of No. 10 and half of No. 12 steel, set on a brick base outside of the building. The feed-water pumps are Stilwell-Bierce & Smith-Vaile duplex 6 ins. by 4 ins. by 6 ins., arranged to pump either directly from the well to the boilers, from the well to the tank, or from the heater to the boilers. At present the pumps are not connected to the well and tank, but water is supplied directly to a tank located just ahead of the stack, whence it flows by gravity into the heater.

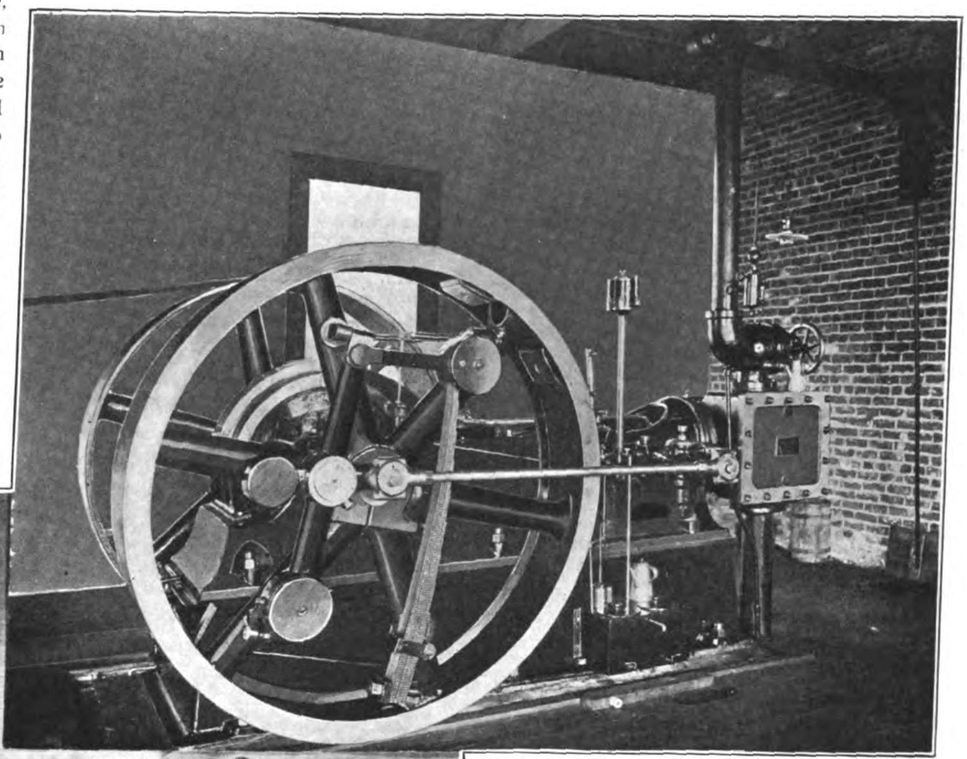


FIG. 2.—CORNER OF ENGINE ROOM OF TALLAHASSEE LIGHTING PLANT.

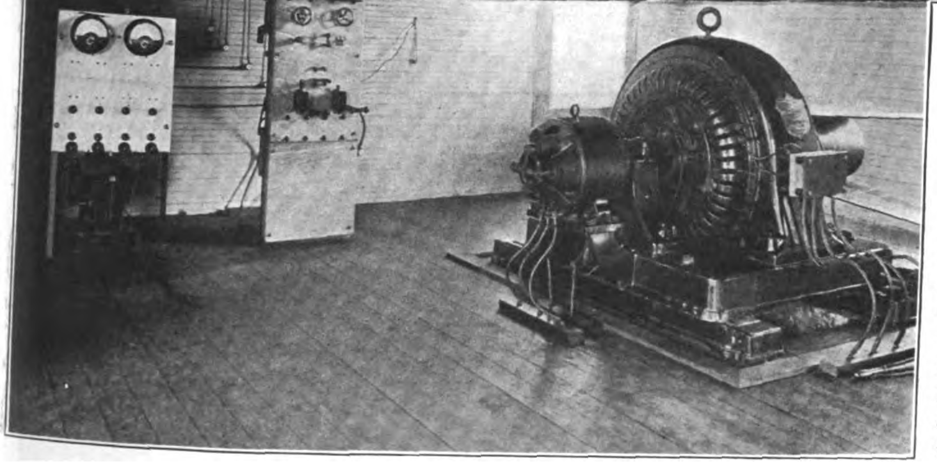


FIG. 1.—VIEW SHOWING SWITCHBOARDS AND GENERATOR OF TALLAHASSEE MUNICIPAL LIGHTING PLANT.

Back of the boilers is located a 300-h.p. Cochran feed-water heater, through which the exhaust from the engine is passed and from which the water goes to the pumps in a line of 3-in. piping. This heater and piping thereto were installed of sufficient capacity so that when another unit was added a minimum amount of change would have to be made, the same provision being made in the steam piping, which consists of 5-in. taps through valves to an 8-in. header, whence a 5-in. line is run to the engine through a Cochran separator. An 8-in. valve is placed between the two boilers so that the units can be separated for repairs, etc.

In the engine room is a 150-h.p. Skinner simple engine driving through an 18-in. belt a 115-kw. 2,300-volt two-phase 60-cycle Bullock revolving-field generator with direct-connected exciter. These are both mounted on substantial concrete foundations (a timber sub-base being used under the generator) with 29-ft. belt centers. Space is left for another unit on the other side of the building. The present engine is a left-hand one, and the new one is to be a right-hand one, so that both belts may be outside and both exciters convenient to the switchboard.

The generator switchboard is of Wagner make and contains two oil switches, field, voltmeter and synchronizing switches, an ammeter for each phase, a field ammeter, a voltmeter, expulsion fuse blocks, and an electrostatic ground detector. The switches were made double throw, so that when the second machine was installed they might be run in parallel or separately as desired. Space is left for a similar panel between the present one and the arc board, which was built by the Helios-Upton Company and controls two arc circuits of 25 lights each through regulators of the Helios-Upton type, which are placed behind the board. The arc circuits are so arranged that either circuit can be thrown on either phase. All the incandescent lighting is on one phase, and the arcs run either all on the opposite one or one circuit on each side, as the lighting load varies.

The street lighting consists of fifty 7½-ampere series enclosed alternating Helios-Upton lamps, hung in the center of the cross streets from Cutter hoods and pulleys at alternate street corners, except in the business section where they are on every corner. On the more densely shaded streets they are hung as low as possible, and thus give very satisfactory service. The incandescent service is from 105-210 three-wire secondaries wherever the business justifies the running of same, the more scattered customers being on single transformers. The following transformers were installed when the plant was started, being partly of Westinghouse and partly of Stanley make: Two 300-light, one 150-light, four 100-light, one 40-light, six 20-light, six 15-light and two 10-light. Stanley lightning arresters are used. The poles are of cypress, from 25 to 40 ft. in height, set from 5 to 5½ ft. in the ground and well guyed at the corners.

The city is now arranging to purchase another unit and will then doubtless do what had to be left undone at first; that is, cover all the steam piping and erect a shed for storing fuel, etc., the original appropriation being inadequate.

TELEPHONE ENGINEERING.

Cables.

BY F. J. DOMMERQUE.

As the cable used for aerial construction is of the same description as underground cable, the following discussion will pertain to both. In the present state of the art the so-called paper or dry-core cable is supreme. Air being the best insulator, manufacturers of cable build their cables with that in view and secure an air-space around and between the conductors in the cable by wrapping one or two strips of thin paper loosely around the bare wire, just enough to keep the wires apart when the outside covering is put on, and when the cable has to undergo certain pressure and bending whenever it is hung up on pole lines or pulled in and out of conduits. The air between the conductors in the cable acts not only as a good insulator but gives also the least electrostatic capacity; the capacity increasing with decreasing distance between the conductors. Therefore, the greater the distance between conductors, the smaller the capacity and the better the cable, other things being equal. To avoid "cross-talk" on the cable, the two conductors forming a circuit are twisted, and finally the twisted pairs are bunched together into a cable, which is covered with a lead sheath to withstand mechanical and chemical influences from the outside.

The wire used in cables is soft-drawn and should have a conductivity of 98 per cent of pure copper. It would be our next problem to discuss this wire again in the same light as we did the wire used for pole lines; but as only the ends of the wire in this case are accessible to the inspector after it is worked up into the cable, we need consider only such data as are of particular value to know.

In cables, naturally, finer wire is employed than in open lines, the following being the usual sizes: Nos. 16, 17, 18, 19, 20 and 22; all B. & S. gauge. It would be only in quite special cases that a wire of larger size would be used. At this juncture it may be opportune to pay some attention to the recent practice of using more No. 22 conductor cable than before, and deviating to some extent from the unwritten law of exclusively open wires for toll and long distance lines by bringing the spurs from the lines at the outskirts of the cities to the exchange in cables. It had been the common rule not to use anything smaller than No. 20 in cables, certainly after the introduction of common battery for signalling and talking, as otherwise the resistance of the lines would become too great. Lately, however, improvements have been made in the manufacture of transmitters of high resistance which will allow the extension of the limits of good transmission simultaneously with the increase of the battery e.m.f. to 50 volts. The equivalent of an increase of the limits of transmission with the old gauge would, of course, be a decrease in the gauge with the old limits.

At the present time there is no difficulty in transmitting current from a common battery for talking through 1000 ohms resistance; which would equal about ten practical wire-miles or five practical circuit-miles of No. 22 conductor, if the wire were straight in the cable; but it is twisted, and therefore the actual length of cable for good transmission would be about 9.6 wire-miles or 4.8 circuit-miles of No. 22. It is therefore in the hands of the constructing engineer to arrange his cable layout so as to use all the No. 22 gauge cable he can, and in as large cables as possible, and so economize in first cost of cables. He would have to take into account also toll service, for which purpose a short piece of cable made up of No. 16 conductors may be required from the exchange to the nearest pole line.

As the inspector may have an opportunity to examine the material at the cable factory before it is manufactured into the cable (though usually the cable is bought according to specifications and tested afterward when in place, to see whether it comes up to specifications, which usually contain a guarantee clause that the cable must retain its specified properties for a number of years), the writer will give some information in regard to the wire employed. What was said before in regard to larger sizes applies in general also to smaller sizes with the corresponding changes in values. Table I gives the ordinary sizes, resistances and weights of cable conductors. The resistance in this table is that of pure copper wire; ordinary commercial copper has a resistance from 3 per cent to 5 per cent higher.

TABLE I.

B. & S. gauge.	Bare diam. in mils.	Resistance in international ohms per 1000 ft. at 68° F. or 20° C.	Weight in lbs. per 1000 ft.
16	50.821	4.009	7.8
17	45.257	5.055	6.2
18	40.303	6.374	4.8
19	35.890	8.038	3.9
20	31.961	10.14	3.0
22	25.346	16.12	1.95

The mechanical properties of the wire used in cables differ from those of the bare wire, as we deal here with soft-drawn copper, the ultimate tensile strength of which varies from 32,000 to 36,000 pounds, while the average for hard-drawn copper is from 60,000 to 68,000 pounds per square inch. The tensile strength of the wire is not of such importance in cables as in open wires, because the cable itself, whether suspended from poles or drawn into conduits, is not subjected to tension except when being pulled up to the poles or into the conduits, and this tension does not affect the wires in the cables. The wire being softer, a greater number of twists can be made by the torsion testing machine per unit of length; any of the conductors from No. 16 down should stand thirty or more twists in two inches.

It may be mentioned that with the introduction of electric welding the cable manufacturers came into possession of wire-welding machines and therefore weld joints in wires electrically. Such welds are not only stronger than soldered or twisted joints, but stronger than the unwelded part of the wire; a welded wire when subjected to tension will not break at the weld but at some other place.

The paper for insulating the conductors of a cable is very thin—about four mils thick—and comes in bands like telegraph paper, about ⅝ inch wide. The machine, when putting the paper on the wire, not only wraps it around the wire spirally so that the edges overlap, but also twists the paper itself while wrapping so as to make it more bulky. Instead of twisting the paper while wrapping it, however, the paper may be fluted or corrugated. It is essential that all paper before being used shall be perfectly dry. If there is the least suspicion that the paper may contain any moisture, it should be kiln dried. The paper on one of each pair of conductors is differently colored from the other conductor in the pair, one usually being red and the other blue, so that the tip or sleeve side of the line can easily be identified when the cable is in place. It is the rule to add one or more odd pairs to the cable either to be used for testing purposes or for reserve. If not otherwise specified, the manufacturer will provide each cable with at least one test pair for each one hundred or fractional part of one hundred pairs of conductors; 400 pair No. 22 gauge cable usually contains 406 pairs. With two wrappings of paper, the wrappings are put on in opposite directions.

The two wires in a pair are twisted so that for all conductors of No. 19 B. & S. gauge and smaller, the twists do not exceed three inches, and for all conductors of No. 16, 17 or 18, six inches. A quarter of an inch variation either way for the smaller, and one-half inch for the larger sizes, however, may be allowed, provided the twists are regular and uniform. The pairs are grouped in layers around one central pair, the pairs in each layer being given a twist not to exceed 24 inches, each consecutive layer being spiraled in reversed direction from the preceding one. To hold the pairs, when formed into this kind of rope, in their position until the lead covering is put on, a cotton thread is wound around them spirally. The cable is then dried either in a vacuum chamber, which is the quickest process, or in an ordinary dry chamber, and a stout spirally wound wrapping of paper is applied over all. The lead sheath is pressed around the cable by a press containing a charge of molten lead. The thickness of the sheath varies according to the size of the cable, and whether it is to be an aerial or underground cable. Different engineers specify different thicknesses of lead. In Tables II and III are given the thicknesses specified by various parties, and the thickness recommended by the writer.

Many engineers specify that the lead used for the sheath should contain three per cent of tin, allowing a variation of 0.15 per cent and sometimes as much as 0.5 per cent either way. It is advisable to use a small percentage of tin to help stiffen the lead cover so that it will not flatten on the reel. Any defects such as cracks, blowholes, pinholes and the like are the greatest enemy of cables, as they permit dampness to enter. Such defects could be ascertained by laying the cable into a water tank, one end sealed, and sending in compressed air at the other end of the cable sheath under a pressure of not over 75 pounds per square inch. If there are any defects in the sheath, air bubbles will show it. But to make such a test would require a more costly plant than practical necessity would warrant, as defects in the sheath of a cable are extremely rare, and such as do exist are very seldom deep enough to allow moisture to enter the cable.

TABLE II.—THICKNESS OF LEAD SHEATH FOR AERIAL CABLES.

No. of pairs.	Variously specified.	Recommended.
10	3/64"; 1/12"; 3/32"	1/16"
25	5/64"; 3/32"; 1/12"	1/12"
50	3/32"; 7/64"	1/10"
75	7/64"; 3/32"	7/64"
100	3/32"; 7/64"; ⅛"	7/64"

It has been the custom of some telephone companies to have the cables wrapped with a saturated braid, with the result that one often sees aerial cables with ragged braid hanging down a few inches all along the line. It is not only the untidy appearance that is an objection against the wrapping on aerial cables, but the impossibility of inspecting the sheath when in place, and defects develop. A braid on underground cables would protect the sheath when pulling the cable in; but after the braid becomes ragged it will be practically impossible to pull the cable out again.

TABLE III.—THICKNESS OF LEAD SHEATH FOR UNDERGROUND CABLES.

No. of pairs.	Variously specified.	Recommended.
25	3/32"; 5/64"; 1/12"	3/32"
50	3/32"; 7/64"	7/64"
100	7/64"; ⅛"	⅛"
150	⅛"	⅛"
200	⅛"	⅛"
250	⅛"; 9/64"	⅛"
300	⅛"; 5/32"	⅛"
400	⅛"; 5/32"	⅛"

Whenever a cable is finished, it must be sealed at the ends immediately, to prevent dampness from entering. For that purpose the two ends are filled with an insulating material, usually melted paraffin, for a distance of at least two feet back; then the ends of the lead sheath are closed over and soldered up, so as to give a hermetic seal. The cable is then wound upon reels, each having a hole cut in one side for the inner end of the cable to pass through. This inner end should protrude at least eighteen inches, so that it can be easily tested before unreeling.

For shipment, a piece of burlap should be wrapped over the outside layer of the cable, and the end that sticks out should be boxed up securely; finally, stout lagging should be screwed on all around the periphery of the reel. It is advisable to mark each reel with the length and size of the cable in large and plain figures that cannot be washed off. The manufacturer, as a rule, will not forget to put on his own name, but he should also put on the name of the purchaser and any designation mark given the particular cable in the specification or order. In addition to marking the outside of the reel, a metal tag may advantageously be attached to the cable itself before it is covered up, upon which the designation mark and other data may be stamped.

When putting the cable upon the reel care must be taken that the cable is rolled tight, but not so tight it loses its cylindrical form and becomes flattened; when unreeled for use it must show no kinks nor flat places. The cable should be able to stand reeling and unreeling at least ten times around a reel having an inside diameter of not more than twenty times the diameter of the cable, without showing flat places or cracks or any defects that would disqualify it.

Abstracts from Foreign Contemporaries

Central Station Records and Returns.—The *Electrical Engineer*, of London, contains a long article by F. H. Davis, on the design of central station records and returns containing the author's ideas as to what books should be kept at a central station. The first book referred to is a diagram book, clearly showing all the cable and pipe work connections strictly up to date. Besides main connections it should contain diagrams of any motor starters or similar apparatus, that may be installed in the station. Daily load curves should also be taken, showing the output in kilowatts over the 24 hours. Cost curves should be constructed, showing the cost of coal, oil, waste, water and engine room stores; wages, repairs and maintenance. A daily log sheet should show the readings of the various instruments, the majority of the readings being taken at least every half hour during light load and every quarter of an hour during the rest of the day. Feed water temperatures should be read by the stokers at stated intervals. The whole sheet should show the following items: Total units generated; units put into battery; units taken out of battery; efficiency of battery, watt-hour and ampere-hour; units used on works; units sent out; pounds of coal per unit generated; pounds of water evaporated per pound of coal consumed; evaporation from and at 212° F. A battery log book should consist of a daily record of the battery charge, discharge and efficiency, and the results of a weekly examination of the battery, specific gravity and volts. Among the other books considered by the author are engine and boiler hour records, balancing book, free wiring book, house service costs, meter cards and books, canvassing records, meter testing records, main testing records, indicator cards, weekly and quarterly returns and balance sheets.

Shock Due to Playing a Stream of Water Against an Electric Conductor.—F. Heinicke contributes to a recent number of the *Elektrotechnische Zeitschrift* an account of experiments carried out at the Charzow power station for the purpose of obtaining some definite information on the danger of shock through directing a stream of water against an electric conductor. A stream of water was directed at a bare wire, through a hose, *A*, having a mouth of 12 mm. diameter, the water being under a pressure of 5 atmospheres. The wire was carried on well-insulated supports and was subjected to the full section of the stream. The difference of potential between the water, *B*, and the earth was measured by means of a standard voltmeter, the copper nozzle of the hose being thoroughly insulated from earth. The experiments were carried out with both direct and alternating currents, the distance, *L*, between the pipe and wires being varied within wide limits. Inasmuch as the quality of the water affected the results, the tests were first carried out with water from the town mains, which was rather hard and poorly conducting, and also with water containing .5 per cent of pure soda. Prof. Weber and Dr. Kath, in a series of exhaustive experiments, both showed that a human being could just endure a current of .03 ampere without fatal results. They also showed that the resistance from hand to earth of a person standing on wet earth is at least 15,000 ohms. Experiments were conducted on a three-phase star-coupled circuit, with 6,000 volts between the lines and an earthed neutral. The wires were bare and well cleansed; each had a section of 95 sq. mm. The tests showed that a distance, *L*, of 300 mm. was sufficient for safety with pure water, while when .5 per cent. of soda was added the distance, *L*, must be increased to about 1,000 mm. before the current falls to .03 ampere. Though this removes the danger, an uncomfortable shock is felt. On a three-phase circuit with 125 volts between the lines, one of the mains, instead of the neutral, was earthed. After the distance, *L*, was reduced as low as 30 mm., the current never reached the limiting value, being only .0024 ampere at 30 mm. with pure water, and .0073 ampere with .5 per cent soda added. On a direct-current traction circuit, supplied from accumulators at 550 volts, with the negative earthed, the limit of .03 was not reached with pure water even with a distance of only 30 mm., the actual current being only .016 ampere. With .5 per cent soda in the water the limit was just reached at 30 mm. and the current was .026 ampere at a distance of 80 mm. On a 240-volt, direct-current circuit, the limiting value is not reached at all after the distance, *L*, was reduced to 50 mm., the current being only .0076 ampere with pure water and .011 with .5 per cent soda solution. From these figures it would seem that the danger from this source is not so great as is usually supposed.

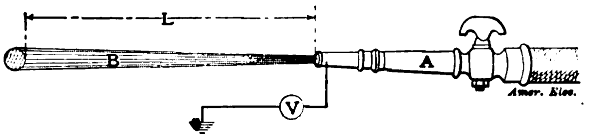


FIG. 1.—DIAGRAM OF CONNECTIONS.

Automatic Car Control.—The London *Electrician* contains a description of a new system of automatic car control. The car on which the new apparatus was installed was a four-wheel double-decker, weighing about 9 tons and equipped with two Brush motors. The alterations in the electrical equipment are as follows: The field windings have been changed from series to shunt with the addition of an auxiliary series winding; the motion of the power handle has been limited to the series notches; a speed control lever has been added, interlocked with the power lever; an automatic switch has been introduced into the emergency circuit to cut out resistances when the line current fails. No change has been made in the armatures or their connections. It is stated that the net saving in energy obtained over a large number of trial runs appears to be about 30 per cent, as measured on the car. Instead of 140 amperes the maximum demand on the line is reduced to 80 amperes per car. Regeneration takes place automatically on a descending grade, or by pulling back the speed lever quickly. In descending hills the regenerative effect is usually 40 amperes, sometimes rising to 50 amperes. There are two handles on the controller, one for the field winding and the other for the armature. The latter cannot be moved until the former is at the notch for maximum excitation of the field, but it can then be advanced to any position. Resistance is gradually inserted into the field circuit to increase the speed by advancing the lever controlling the field resistances. Should it be desired to decrease the speed or to cause the motors to generate and return current to the line, it is only necessary to move this lever backward, thus cutting resistance out and providing an exceedingly strong field. When this lever reaches the position in which all resistance has been cut out, the armature lever flies back and breaks the circuit unless it is purposely held forward. Owing to shunt motors being employed, current is returned to the line automatically when the car descends a gradient. If the trolley comes off the line, the motorman has merely to press a small handle attached to the field resistance lever, which switches in a series winding, consisting of many turns of fine wire, and short-circuits the motor. It is perfectly immaterial as to what position each lever is in when this operation is performed. The effect is exactly the same whether the car goes forward or commences to run backward; immediately after the auxiliary series winding is connected, the car is pulled up almost to a standstill and may be brought to a dead stop by means of hand brakes.

Forbes Grip Nut.—Fig. 3 herewith shows a grip nut which is said to be especially applicable to motor car work. The nut consists of two parts, although one of these is but a washer; yet the one without the other is of no use. In Fig. 2 the top of the screw bolt is shown coming through the washer. The hole in the latter is tapered, the latter diameter of hole being at the top. It will be seen that this hole is considerably larger than the bolt. In this figure the nut proper is seen on the right-hand side. It is much deeper than an ordinary nut, and its lower portion is turned off parallel and has four slots cut in it. The size of this turned-off portion is such that it just enters the hole in its washer, and, since the latter is tapered, and since the extension of the nut is slotted, a gripping action on the bolt is set up as soon as the nut enters the washer hole. Moreover, the grip gets greater as the nut is screwed further and further "home." Fig. 3 shows the nut screwed right "home." A number of advantages are claimed for this nut: First, that it has three pressures, viz., (1) Face pressure, as an ordinary nut; (2) friction pressure between the extension of the nut and the washer; and (3) the pressure of the thread inside the extension of the nut and the thread of the bolt. It is further claimed as an advantage that it is free from springs, extra screws or any complication; that since the inside of the washer is tapered and smooth, the nut is as easy to screw off as to screw on, and can be used any number of times. We are indebted to the London *Engineer* for the foregoing description.

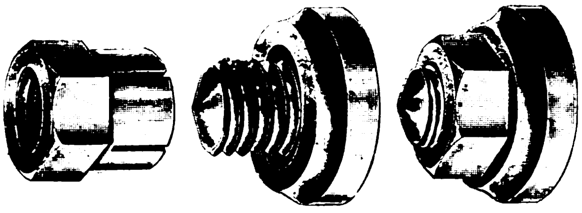


FIG. 2.—FORBES GRIP NUT.—FIG. 3.

Arrangement and Control of Long-Distance Transmission Lines.—E. W. Cowan and L. Andrews, in a paper presented before the Manchester Section of the British Institution of Electrical Engineers review briefly the different current distribution systems. The authors say that the maximum pressure for three-phase alternating-current distribution actually in practical operation is 80,000 volts. There is, they say, no reason why this should be the limit, as transformers have been worked well above 100,000 volts, and with liberal spacing of the overhead wires the electrostatic leakage can be sufficiently reduced. After touching on the line capacity current, the loss in conductors, poles, etc., the authors describe the winding and arrangement of an improved variable induction transformer.

Fig. 4 shows the winding and arrangement of core in the position of zero secondary pressure. Instead of the secondary winding being wound entirely upon the ring, it is wound half on the movable core and half on the ring. The primary winding is wound on the movable core. The result of this arrangement is that the magnetic lines induced by the primary winding cut the half of the secondary wound on the movable core in a positive sense, and the half of the secondary on the ring in a negative sense in the relative position shown. The resultant e.m.f. in the secondary is, therefore, *nil*. In Fig. 5, however, the movable core has been rotated through an angle of 180°, and the magnetic lines cut both the secondary windings in a positive sense, the resultant e.m.f. being the sum of the two, and, therefore, a maximum. In intermediate positions, intermediate secondary pressures are obtained. There is practically no magnetic leakage between the primary winding and the half of the secondary winding on the movable core, and the number of secondary turns on the iron ring being half of the total, the tendency for magnetic leakage to occur at the air-gap is proportionately reduced. The result is that there is only a total drop of 6 to 7 per cent on the secondary between no load and full load. A further improvement consists in fixing shading coils on the movable core in the positions shown, and marked *s c* in the diagram. These shading coils neutralize the inductance of the secondary circuit when the movable core is in intermediate positions. The slots in the ring which contain the secondary coils are so placed that the area of gap between movable core and ring is as large and as equal as possible in all positions, thereby keeping the magnetizing current as low and as constant as possible. The paper concludes with a description of a modification of the discriminating transformer, which may be used with alternating-current generators connected in parallel, for the purpose of indicating whether a generator is feeding the bus-bars or receiving current therefrom. Without some device of this character, the attendant has nothing to indicate, in the event of a failure, which generator to switch out, as the fault will cause the ammeters on both the defective and the other machines to indicate an excess current. The discriminating transformer is connected as shown in the adjoining figure. Red and green lamps, *A* and *B*, are connected respectively across the terminals of two secondary windings. A primary winding is connected directly across the bus-bars or across any secondary circuit excited from the main bus-bars. The effect of this primary winding is to induce a magnetic flux in the core of the transformer indicated by the thin arrows. A second primary winding, *D*, consists of one or two turns inserted in series with the generator connections. The effect of a generating current in this winding is to induce a flux in the direction shown by the thick arrows. The fluxes due to the two primaries oppose each other through the secondary connected to the red lamp, and assist each other to light the green lamp. Should the generator fail the direction of the series flux relative to the shunt flux will be reversed, and as a consequence the green lamp will be extinguished and the red lamp lighted. The authors state that this current direction indicator has also proved of great assistance in disconnecting machines which were in parallel.

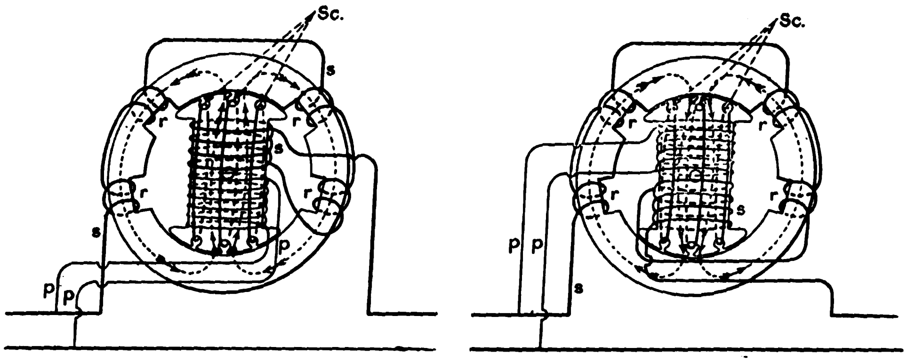


FIG. 4.—REGULATING TRANSFORMER IN POSITION OF ZERO AND MAXIMUM SECONDARY E.M.F.—FIG. 5.

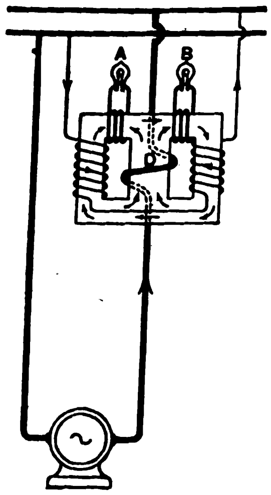


FIG. 6.—DISCRIMINATING TRANSFORMER.

Electric Safety Devices for Low Potential Current Installations.—H. C. Steidle discusses, in a recent issue of the *Elektrotechnische Zeitschrift*, the principles of the arrangement of efficient safety devices for low-potential installations in order to protect them as well against lightning as against dangers resulting from their transmission lines coming into accidental contact with high-potential current lines. The author describes a new construction which he has devised, and which is illustrated in Fig. 7. It consists essentially of a rod, *d*, to which the transmission wire is connected. The wire entering the station is connected with the metallic receptacle, *f*. A cone, *k*, of insulating material separates one from the other. Connection between the two is made by means of a wire spiral, *h*. The core, *z*, of the spiral consists of a celluloid rod. In cases where the intensity of the current entering the device is only a little above that which the device can carry, the spiral simply burns out. But under the action of a high-potential current, not only will the spiral burn out in the first place, but there will be an arc produced between the two wires. The heat of the arc will then burn the celluloid core and thus produce a violent explosion, which has the effect of bursting the apparatus and thus disconnecting the two wires. The author states that experiments have been conducted with pressures up to 5,000 volts, showing that the separation is quickly and effectively accomplished.

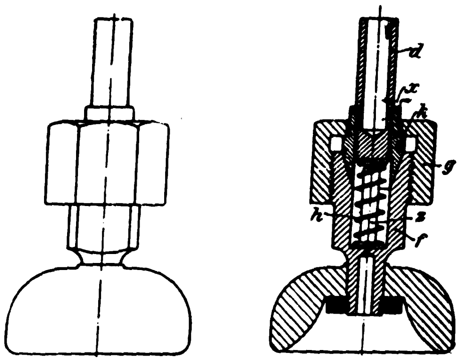


FIG. 7.—SAFETY DEVICE FOR LOW-POTENTIAL INSTALLATIONS.

Electrolytic Apparatus.—Owing to the great expense of platinum and the necessity for its use in electrochemical analysis, various forms of electrodes have been devised with a view to reducing this cost. Dr. F. M. Perkin describes in a recent number of the London *Electrician*, a comparatively inexpensive yet very satisfactory form of electrode. Referring to Fig. 8, it will be noticed that the cathode is in the form of a flag. This is made of platinum gauze and is held rigid by means of a platino-iridium frame containing 10 per cent of iridium. The frame is roughened by means of a sand blast and has a stout piece of iridio-platinum wire welded to it. The loop in the top of the wire is for hanging the elec-

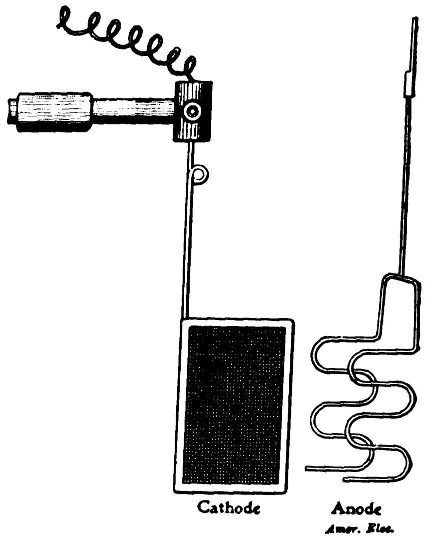


FIG. 8.—ELECTRODES FOR ELECTROLYTIC APPARATUS.

trode on the balance. The anode is made of iridio-platinum wire bent upon itself in such a way that when it is placed in position for electrolysis an even current density is obtained on all parts of the cathode. The distance between the two sides of the anode is 2.5 cm.; therefore, when in position it is 1.25 cm. distant from each side of the cathode. The latter is 6 cm. high and 4.3 cm. wide; the length of the supporting wire being 7.5 cm. and the loop being 2.5 cm. from the end. As the anode is opposed to both sides of the cathode during electrolysis, it follows from the above measurements that the total cathode surface is 50.4^2 cm.; that is, practically half a square decimeter, which, as the current density for analytical purposes is generally calculated per square decimeter of surface, is a very convenient size. It is not essential for the cathode to be made of gauze; in many cases sheet platinum is quite as useful, but for metallic deposits which are inclined to exfoliate, such as bismuth and antimony, the gauze is more satisfactory; it is also very useful for mercury and peroxide deposits. The gauze should not be too fine, 50 to 60 meshes to the square centimeter having been found satisfactory. When the gauze is too fine there is a tendency for hydrogen to collect on the surface and thus cause polarization. The weight of the cathode when made of platinum sheet is 14.5 grammes. If finer platinum be employed the weight can be reduced to 8 grammes, but experience has shown that it is better not to have cathodes of too thin platinum since these are so fragile that there is a tendency for the deposits not to adhere well at the edges. The weight of the gauze electrode is about 15 grammes. These electrodes are more satisfactory for carrying out electrolytic separations, since manipulation is much easier than with the basin.

SOME RECENT ELECTRICAL PATENTS

High-Tension Insulator.—Figs. 1 and 2 herewith illustrate a method of construction for insulators to be used on lines of very high voltage, which has been patented by Vernon G. Converse. The fundamental object of the invention, of course, is to secure maximum insulation between the pin and that part of the insulator to which the transmission wire is attached; the next object is to facilitate the manufacture of high-tension insulators, which are necessarily of large diameter. The inventor uses a sheath, 2, which is screwed to the pin, 3, in the usual manner, and almost entirely shrouds it; because of the difficulty of manufacturing large insulators in a single piece, the bell of the insulator is made in a separate piece from the sheath and attached to the latter preferably by means of a second and entirely enclosed pin, 6, Fig. 1. The two sections of the insulator, 1 and 2, are kept out of contact by means of a washer, 7, of felt or other soft material, the object of which is to prevent grinding between the two pieces when the bell is screwed into place. In Fig. 2 substantially the same construction is shown, except that the two halves of the insulator are held together by means of a sleeve, 17, instead of the internal pin, 6, shown in Fig. 1. This sleeve is made of fibre or any non-conducting material having sufficient mechanical strength. Both of these constructions, it will be noted, interpose two sections of solid insulation between the end of the main pin, 3, and that point of the bell where the wire is located, as well as lengthening the air distance from the wire to the pin by enclosing the shank of the pin down to within a short distance of the cross arm. Patent 735,212.

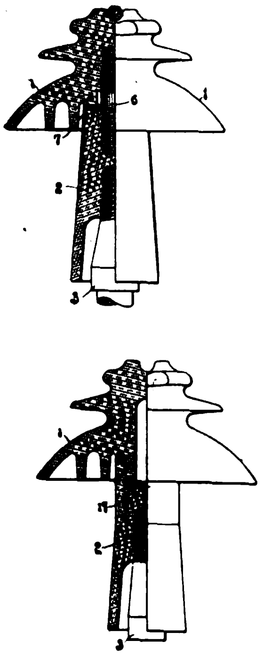
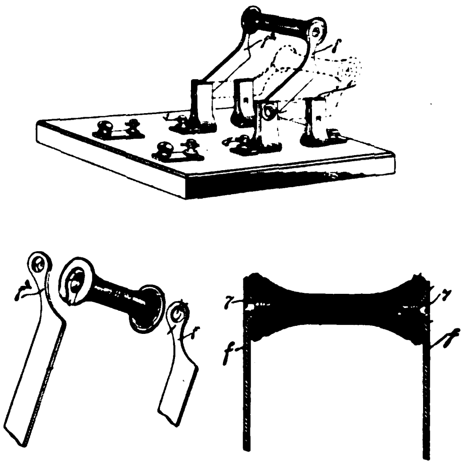


FIG. 1 AND 2.

Knife Switch.—One of the small but none the less annoying disadvantages common to most forms of knife blade switch is the tendency of the screws holding the cross-bar and handle to work loose. Figs. 3 and 4 illustrate constructional features devised by Hans O. Swoboda for the purpose of eliminating this disadvantage, and also rendering the familiar double-pole switch easier of manipulation. The inventor uses a round cross-bar which also serves as a handle, and in order to prevent the screws from working loose under the influence of the swiveling motion which the handle would naturally be given in the manipulation of the switch, the ends of the blades are secured to the handle in such a manner as to prevent the latter from turning on the screws. Figs. 4 and 5 illustrate one method of accomplishing this; the ends of the knife blades have conical projections which fit into tapered holes in the ends of the handle, and the narrow portion of the blade ends, *f*, fits into a slot in the end of the handle. This latter feature prevents the handle from turning, and the conical fitting serves as a wedge to bind the retaining screws, 7, and restrain them from jarring loose. Patent 735,841.



FIGS. 3, 4 AND 5.—KNIFE SWITCH.

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NOTES.

The American Street Railway Association.—At the twenty-second annual meeting of the American Street Railway Association, which will be held at the Grand Union Hotel, Saratoga Springs, N. Y., Wednesday, Thursday and Friday, September 2, 3, 4, papers will be presented on "Steam Turbines," "Electric Welded Joints," "The Evils of Maintenance and Champerty in Personal Injury Cases," "Train Orders and Train Signals on Interurban Roads," "Freight and Express on Electric Railways," "The Manufacture and Distribution of Alternating Currents for City Systems," "Comparative Merits of Single and Double Truck Cars for City Service," and "The Right of Way." The Association expects to have the largest exhibition of street railway supplies ever shown at any of its conventions.

Association of Edison Illuminating Companies.—As previously announced, the twenty-fourth convention (nineteenth annual meeting) of this association will be held at the Frontenac, Thousand Islands, N. Y., commencing Tuesday, September 8. We give below a list of the papers expected to be read: "Commercial Experience with Nernst and Meridian Lamps," by W. B. Thompson, Detroit; "Purchased Electric Power in Factories," by E. W. Lloyd, Chicago; "Operating Features of High-Tension Power Stations," by W. F. Wells, New York; "Position of Steam Turbines in Central Station Operation," by August Kreusi, Schenectady, N. Y.; "Overhead Pole Line Construction and Operation," by A. H. Manwaring and J. T. Hutchings, Philadelphia; "Comparison of European and American Engineering Practice," by Charles Schwartz, Chicago; "Profitable Advertising," by W. H. Johnson, Philadelphia; "The Central Station and the Isolated Plant," by Douglass Burnett, New York; "Depreciation in Electric Light Plants: How Estimated and Applied," by H. M. Edwards, New York; "Selection and Installation of High-Tension Switching Apparatus," by Leonard L. Elden, Boston; "Illumination," by Charles P. Steinmetz, Scheneetady; "Results Obtained with Steam Turbines in Milan, Italy," by Guido Semenza, Milan, Italy; "The Development of Summer Lighting," by E. A. Leslie, Brooklyn, N. Y., and "Notes on Commercial Features of European Lighting Practice," by Arthur Williams, New York.

Compensating Fluctuations of Load in Power Transmission Plants.—The design and arrangement of "buffer" machines, *i.e.*, flywheel dynamos, intended to compensate fluctuations in the load of power plants, was the subject of a lecture recently delivered in Berlin by Herr Meyersberg. Such fluctuations occur with especial frequency in mines, where working periods are followed by more or less prolonged pauses, and also in rolling-mill plants, where violent shocks of load frequently take place. These buffer machines are coupled to heavy fly-masses, in which at times of light load energy is stored up, to be given out later with heavier loads. In a system patented by the Union Electric Company, the buffer machine is inserted in the line between the supply generator and the hoisting motor; the machine is series-wound, the field winding being in the main line, but the armature is connected across the line. The motors being switched off, the machine acts like an ordinary series motor, accelerating its flywheel and storing energy therein. When any of the motors are cut into circuit, more current flows, resulting in a stronger field in the buffer machine, and a higher counter e.m.f. The strength of the current supplied eventually decreases again, even changing sign, when the machine will act as an independently started dynamo. There is a shunt winding on the machine, weakened by a resistance so as not to be efficient under normal working conditions. In order, however, that the buffer machine may not run away during prolonged pauses, a centrifugal pendulum is provided, which, at a predetermined speed, will cut out the shunt resistance so as to cause the shunt winding to become effective.

A Municipal Steam Turbine Plant.—An interesting municipal electric lighting plant enterprise is under way at Anderson, Ind., which will be the second introduction of the steam turbine in American municipal lighting plant service. The city of Anderson has for some years operated an electric light plant in connection with the city waterworks, located near White River. The electric installation is housed in a separate building, adjacent to the water-works plant, the boilers of which furnish the steam necessary for the operation of the electric light engines. The present lighting equipment comprises two belted generating units, but the increasing demand for light and power renders the available capacity inadequate to carry even the present load, at times resulting in a severe overloading of the entire equipment. In order to secure immediate relief from these conditions and avoid the necessity of erecting additions to the power house, Westinghouse steam turbine-alternator units have been selected for power extensions. At first two 400-kw. units will be installed. As the result of the employment of turbines in this plant it has been found possible to install a complete boiler plant in the electric light building, thus rendering the operation of the lighting system entirely independent of the water-works system. The new boiler plant consists of three 310-h.p. Stirling water-tube boilers equipped with Roney mechanical stokers. The boilers will not be arranged for superheat, but will supply saturated steam to the turbines at 150 lbs. pressure, all condensation being returned to the boilers by a steam loop and Holly gravity return system. The generators will furnish three-phase currents to the distributing system at 2200 volts and a frequency of 60 cycles, no step-down transformers being used. The turbine equipment will operate condensing; the plant is located near the river bank. Surface condensers will be used and the condensation from the turbines will be returned directly to the boilers. Mr. E. R. Vincent, of Indianapolis, Ind., has been retained by the city of Anderson as consulting engineer, and the installation is under his general supervision.

American Electric Light and Power Plant Statistics.—Hon. S. N. D. North, director of the United States Census Office, gave to the press lately a preliminary report on the statistics of the electric light and power industry, as compiled by Mr. W. M. Steuart, chief statistician of the department of manufactures, with the cooperation of Mr. T. C. Martin, special expert agent. The statistics of the street railway industry were similarly issued a few months ago, and the figures of the telephone industry will, in turn, follow in a few months, and the telegraph industry will come last of all. The figures given below are for the results at the end of the year closing June 30, 1902. The report includes central stations only, and does not embrace any isolated plants, plants operated by electric railway companies or idle plants, or plants under construction. The street railway census showed 118 trolley companies to be in the light and power business, earning gross from it $6,469,726, and all told, this item, including sale of current, reached $7,703,574.

The final report will contain an analysis of the above totals, and present detailed statistics by States and for other phases of the industry. The statistics for this industry given by the census of 1890 were confined to the State of New York, the city of St. Louis and the District of Columbia, therefore no comparison can be made with the totals for the United States.

CENTRAL ELECTRIC LIGHT AND POWER STATIONS:

	Private.	Municipal.	Total.
Number of establishments	2.804	815	3,619
Cost of plants	$480,161,038	$22,020,473	$502,181,511
Earnings from operation, total	76,748,554	6,836,856	83,585,410
From light service	62,983,068	6,748.863	69,731,931
Arc lighting	22,070,192	3,389,245	25,459,437
Commercial or private	8,203,114	240,166	8,443,280
Public	13,867,078	*3,149,079	17,016,157
Incandescent lighting	40,912,876	3,350,618	44,272,494
Commercial or private	38,668,096	2,868,296	41,536,392
Public	2,244,780	*491,322	2,736,102
All other electrical service	13,765,486	87,993	13,853,479
Income from all other service	1,431,764	128,249	1,560,013
Gross income	78,180,318	6,965,105	85,145,423
Expenses:			
Total	62,442,088	5,245,987	67,688,075
Salaries and wages	18,672,267	1,879,722	20,551,989
Supplies and materials	20,392,467	2,422,291	22,814,758
Rent of stations and offices	1,270,798	14,748	1,285,546
Taxes	2,643,945	10,120	2,654,065
Insurance	820,804	65,641	886,445
Miscellaneous	6.645,567	348,660	6,994,227
Interest on bonds	11,996,240	504,805	12,501,045
Power-plant equipment:			
Steam engines—			
Number	4.861	1,060	5,921
Horse-power	1,230,023	147,018	1,377,041
Water wheels—			
Number	1,296	82	1,378
Horse-power	369,916	11,218	381,134
Generating plant:			
Dynamos—			
Direct-current, constant voltage—			
Number	3.402	418	3,820
Horse-power	418,088	23,533	441,621
Direct-current, constant amperage—			
Number	2,955	582	3,537
Horse-power	157,668	37,763	195,431
Alternating current—			
Number	4,284	822	5,106
Horse-power	887,740	90,688	978,428
Output of station:			
Kilowatt hours—total for year	2,241,314,293	195,904,439	2,437,218,732
Line construction:			
Miles of mains and feeders	10,936,603	1,533,891	12,470,494
Lighting service:			
Arc lamps—			
Total number	334,413	50,795	385,208
Commercial or private	167,709	5,793	173,502
Public	166,704	45,002	211,706
Incandescent lamps—			
Total number	16,429,060	1,577,461	18,066,521
Commercial or private	16,058,111	1,494,645	17,552,756
Public	370,949	82,816	453,765
Average number of employees and total salaries and wages:			
Salaried officials and clerks	6,026	950	6,976
Salaries	$5,175,499	$457,381	$5,632,880
Wage earners	20,791	2,467	23,258
Wages	$13,496,768	$1,422,341	$14,919,109
Foremen and inspectors	1,478	82	1,560
Wages	$1,297,585	$60,687	$1,358,272
Engineers and firemen	6,671	1,349	8,020
Wages	$4,416,929	$785,059	$5,201,988
Linemen	3,860	349	4,209
Wages	$2,503,957	$200,572	$2,704,529
All other employees	8,782	687	9,469
Wages	$5,278,297	$376,023	$5,654,320

*Estimated value if paid for at prevailing rates.

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Changes in advertisements should reach the office of the American Electrician by the 15th of each month in order to appear in the following issue. New advertisements can be received up to the 25th of each month.

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CONTENTS.

Electrical Equipment of the Central Railroad Shops at Elizabethport, N. J. 435
The Choice of High-Tension Insulators, by H. C. Knowlton 439
Measuring the Power of Machine Tools, by George E. Walsh 440
Automatic Block Signals for Railroads, by Ralph Scott 441
The Municipal Lighting Plant at Tallahassee, Fla., by L. A. Poole 447
Telephone Engineering, by F. J. Dommerque 448
Abstracts from Foreign Contemporaries 449
Some Recent Electrical Patents 452
Notes 452
Editorial 454
Design for a Two-Horse-Power Self-Starting Single-Phase Induction Motor 456
Operation of Rotary Converters, by W. T. Fernandez 458
Measurement of Power in Alternating-Current Circuits, by Nathaniel R. Craighill .. 460
The Practical Storage Battery Operation, by H. P. Liversidge 462
Lessons in Practical Electricity 465
Letters on Practical Subjects 466
Queries and Answers 468
The Mechanical Equipment of the Orange Brewery, Orange, N. J. 469
The Electrical Power Installation of the Industrial Works of Bay City, Mich........ 470
An Improved Boiler Cleaner 471
New Apparatus and Appliances 472
New Book ....Adv. 51
Personal ....Adv. 51
Trade Publications ....Adv. 51
Business News ....Adv. 51

Conductor Subways for Isolated Plants.

One of the several very interesting features of the railroad shops' lighting and power plant described in our leading article this month is the location of the electrical conductors and steam pipes which connect the apparatus in the different buildings of the plant. These are located in spacious tunnels of concrete, within which workmen may inspect, repair or change any of the connecting links of the system in absolute safety and comfort, regardless of weather or other outdoor conditions. This arrangement has been used in several modern private plants spread throughout a plurality of buildings, and it cannot be too highly commended. Immunity from climatic influences and mechanical interference, and perfect accessibility to the proper parties, are the two most valuable characteristics to be given to the arteries of any system involving transmission of energy, assuming, of course, correct design in the first place; and the tunnel method certainly fulfils the requirements of the case as no other can.

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Precautions Against Underground Railway Dangers.

The recent horrible catastrophe in the tunnel of the Paris Metropolitan Railway has, very naturally, furnished a text for numerous open letters, articles and editorial comments in the lay and technical press concerning the precautions which should be taken by the management to minimize the danger to life which any accident on such a system necessarily entails. The great loss of life by fire and suffocation which resulted from the Paris accident has inspired all sorts of suggestions as to the car construction to be adopted for the New York Subway system, including the use of fire-proofed wood, and no wood at all; most of the kindly advice being utterly unpractical, of course, as always will be true in such circumstances. Nothing pleases a layman more than to indicate to experienced engineers just what they ought to do in any given case—according to the layman's superior judgment.

Non-inflammable cars, which are being so vehemently advocated just now for the New York underground railway, are eminently desirable, provided that making them fireproof does not impair some other vitally important feature, such as minimum liability to demolition by impact with other heavy bodies, moving or stationary. We do not affect to possess expert knowledge on the subject of car building, but it is our firm conviction that if in the installation of the electrical equipment on each car every known precaution against the formation of arcs and the overheating of conductors be taken, the cars might safely be built of resinous pine, so far as fire danger alone is concerned. The best way to guard against disaster is to forestall fundamental, not secondary, causes of it. In the case under discussion it seems obvious that the most sensible procedure would be to take every possible precaution against the "short-circuits," "open arcs," "faulty splices," etc., so frequently referred to as being "inevitable," rather than weakly to concede their inevitability and grope around for unknown means of minimizing their results.

The real reason for accidents such as that at Paris is not inadequacy of engineering resources, but a semi-criminal willingness on somebody's part to save money at the expense of human safety. Given *carte blanche* in the matter of roadbed and car equipment, there are dozens of engineers in this country capable of installing a subway system that could not be made to produce a fire of electric origin in the tunnel under any conceivable conditions, and we have every reason to believe that such an equipment will be installed in the rapid transit subway here.

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The Capacity of Transmission Lines.

Referring to the condenser effect (static capacity) of a transmission line, by some unaccountable mental freak the statement was made in our columns last month that "the closer the wires are to each other, the lower will be the capacity." Every one who is at all familiar with the elementary principles of alternating-current phenomena knows, of course, that the statement should have been exactly reversed. The condensance or capacity of any two parallel conductors *increases* as the distance between them decreases, the variation for round wires of non-magnetic material being proportional to $\dfrac{1}{\log \dfrac{2D}{d}}$; D being the inter-axial distance and d the diameter of each wire. The error, however, has no material bearing upon the remainder of our discussion of the subject of alternating-current frequency, but we should have pointed out that it is impracticable to reduce the capacity of a transmission line by separating the wires to great distances, for constructional reasons, and it is not practicable to compensate the capacity sufficiently by increasing the inductance of the circuit, except by using special inductance coils, on the principle of the Pupin system.

We have no theory upon which to base an explanation of the mortifying error above mentioned, and shall attempt none. The present correction is made chiefly for the purpose of setting right any readers who may have been misled by the original statement, and only incidentally to clear ourselves of a possible charge of ignorance by confessing what is worse—carelessness, or something very near it.

That "Deadly" Third Rail.

One is almost periodically regaled nowadays with thrilling accounts by the daily press of spectacular tragedies said to be enacted on the roadway of some one of the elevated railways, and (at less frequent intervals, to be sure) with hysterical denunciations of the reckless managerial policy which involves an alleged wholesale sacrifice of human beings by the continued use of the "deadly" or "heavily-charged" unprotected third-rail conductor. When allowance is made for the deliberate distortions of the sensational papers and the exaggerations of the others due to the natural excitement of non-technical reporters, nothing remains on which to hang a rational criticism of the use of an unprotected conductor on an elevated railway, so far as danger to life is concerned. With the rail laid between the wooden guard timbers, as on the Manhattan tracks, a person would have to fall in a most improbable attitude in order to establish any contact with both the conductor rail and a track rail which would not be immediately broken either by the involuntary muscular movement of the victim or the inertia of his body. The accidents that have occurred thus far to workmen have not been due to any such falling, but to neglect of the ordinary precautions that any sensible person may reasonably be expected to take. For example, one man "inadvertently" laid a steel tool against the conductor rail while he was in contact with the track rail. One might as well talk of "inadvertently" depositing a red-hot coal in a keg of giant powder, or "inadvertently" tapping with a hammer upon a stick of dynamite.

The third rails in the rapid transit subway will be hooded, and this is an eminently proper precaution for such a system. In the event of an accident to a train, passengers might be compelled to walk along the roadbed to the nearest station; moreover, it might easily happen that the opening of a circuit-breaker would extinguish the lights in a section of the tunnel where workmen were engaged, leaving the tunnel dark and rendering it difficult to cross the tracks without getting shocks. No such contingencies are necessarily involved in the case of an elevated road. Such roads should be provided with a walk-way along each edge which persons could traverse safely without previous acrobatic training; this would remove the necessity for proximity to the conductor rails on the part of passengers, except under accidental conditions of such extraordinary character as would render all practical precautions futile.

It does not follow, however, that the use of unprotected conductor rails on elevated roads is the best engineering practice. Last winter's experience demonstrated so emphatically the faultiness of a combination of unprotected rails and inefficient scrapers that unless the expense of keeping the rails always workably clean would be less than the increase in fixed and operating charges entailed by hooding them, the latter obviously would be justified on the score of greater reliability of operation in bad winter weather. A hooded rail, however, would not necessarily be any less dangerous to reasonably careful workmen than is the uncovered rail between guard timbers.

The Confidence of Ignorance.

The old adage concerning fools and angels has been exemplified so often and with such diversity of detail that there is small excuse for wonder at the most sublime exhibition of ignorant self-confidence that may occur. One constantly finds men of scanty experience, or none at all, in some line of semi-technical work obtaining positions or contract work in that line by dint of brazen claims of qualifications the non-existence of which might be proved by the most superficial investigation. The result is almost always one of two alternatives: the imposter either "falls down" and loses his "job" ignominiously at once, or retains it for a more or less brief period by making a subordinate do the work which he is incapable of doing. It would seem that this class of parasite would learn a moiety of wisdom by successive failures or repeated demonstrations of his own inferiority to his subordinates, but apparently he doesn't. In the event of flat failure he merely regrets the inconvenience of finding another "job"; when he can sail under false colors awhile at someone else's expense he indulges in self-gratulation upon his astuteness, and possibly increases his insolent arrogance toward his saving subordinate. Never by any possibility does he endeavor by self-education to lift himself above the need to masquerade.

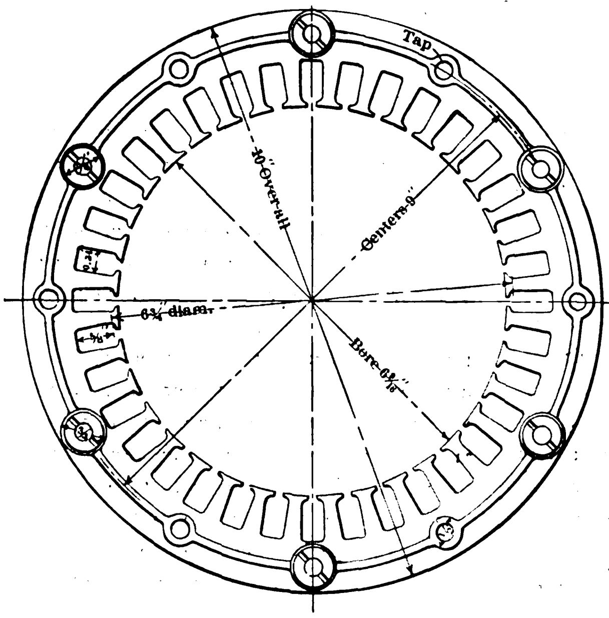
The mentality and character of men of the class mentioned furnish inexhaustible subjects for psychical and ethological study to those who care for such. To the plain conscientious worker in the same field with the parasite, however, he appears merely an embodiment of astounding impudence, mendacity and self-assurance. We have encountered him in almost every branch of the electrical industry, and familiar as his make-up is, we confess to have marveled greatly many times at his unbounded foolhardiness, as well as the total absence of the spirit of self-preservation which would lead a saner man to improve his mental and manual qualifications, or else migrate into a more profitable field of imposture. When a man undertakes to hold a position as chief armature winder without knowing what a lap winding is, or attempts to take care of a long-range Corliss engine in blissful ignorance of the "reason why there are two eccentrics," it would seem that the first experience would cause his bump of self-sufficiency to shrink tremendously. The amazing fact remains, however, that in nine cases out of ten no such effect is produced.

Transformer Regulation.

The rather interesting inquiry "why cannot a transformer be wound for perfectly constant secondary e.m.f., like a dynamo?" has been made at intervals by several readers. The answer, of course, is that any windings that may be added on the same core have only the effect of so many more turns in the original windings and cannot increase the induced e.m.f. without increasing the internal drop in practically the same proportion. It is a somewhat fascinating problem for students, but there is nothing in it. The secondary e.m.f. can be "boosted," of course, by a separate smaller transformer in the well-known manner, and if the game were worth the candle a large transformer could easily be built with a smaller boosting transformer enclosed in its case, thus giving in effect a compounded transformer. In commercial practice, however, the "drop" in a transformer is so small that the advantage obtainable by such an expedient would not justify half of the extra expense entailed. A transformer of medium size is inherently self-regulating within 2 per cent, which is sufficient for all ordinary purposes.

DESIGN FOR A TWO HORSE-POWER SELF-STARTING SINGLE-PHASE INDUCTION MOTOR.

The accompanying drawings give all of the essential features of a self-starting induction motor capable of giving two brake horse-power on a single-phase circuit of 100 volts and 125 to 133 cycles. The speed of the machine will depend, of course, primarily upon the frequency of the supply current. The synchronous speed at 125 cycles is 2,500, and at 133 cycles it is 2,666 r.p.m. The actual full-load speed will be something like 2,300 r.p.m. at 125 cycles and about 2,640 r.p.m. at 133 cycles.



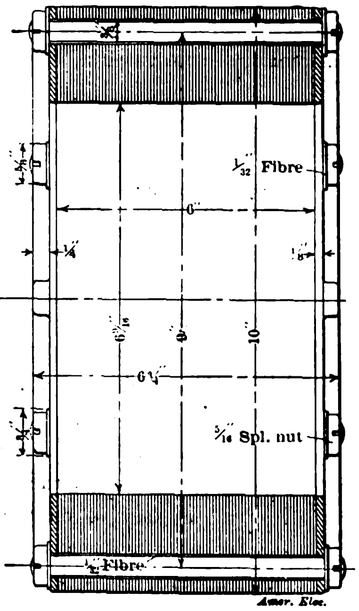


FIG. 1.—END VIEW AND AXIAL SECTION OF STATOR.—FIG. 2.

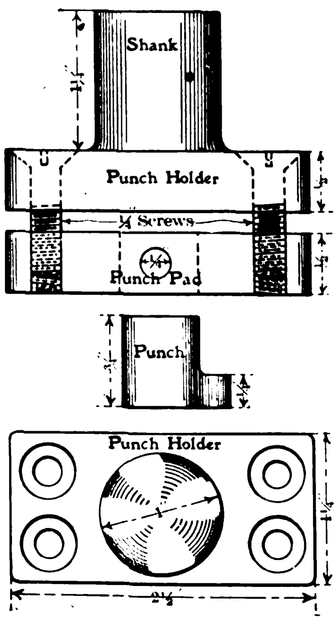
THE STATOR.

Fig. 1 is an end view of the stator and Fig. 2 is an axial section of it, showing the arrangement of the brass end plates and the bolts that hold the structure together. The stator core is built up of 270 discs of sheet steel, each 20 mils thick, and allowing for scale and irregularities, the mass should be drawn together tightly enough to make the axial thickness 6 inches, as indicated in the engraving. The stator discs are 9 inches in diameter outside, and the hole in the center is 6 9-16 inches in diameter; this latter measurement must be absolutely exact. The 36 slots around the edge of the central hole are to be punched by means of the simple punch and die shown by Figs. 3 and 4, these being used in a step-by-step notching press. It is not assumed that the builder will possess one of these presses or buy one for the purpose of building this one motor; but he can easily make the punch and die and have the work done at some shop where such presses are in use.

THE PUNCH.

The punch is built up in three pieces, a shank and holder plate of cast iron, a punch pad of ordinary machine steel, and the punch proper, of annealed steel. The punch pad is a simple rectangular plate in the center of which is worked a socket for the punch, the outline of this socket being the same as that of the main portion of the opening in the die. The punch is, of course, of the same outline on its face as the complete opening in the die, and the upper part of it is to be made a very snug fit in the hole in the punch pad. The latter is secured to the punch holder by means of four ¼-in. flat-head machine screws. In machining the holder, great care must be taken to have the face of it absolutely at right angles with the axis of the shank. The wall of the socket in the punch pad must also be precisely at right angles with the face that matches the face of the holder plate.

Fig. 3 shows the punch pad partly unscrewed from the holder, and the punch removed from its socket; it is held in the socket by means of a ¼-in. round-nosed set-screw, and a depression should be machined in the side of the punch to allow the nose of the set-screw to seat itself without having to burr the punch. After the punch has been filed to shape, it must be tempered. In first hardening it, the steel should be heated to a bright red and "quenched" in oil or lukewarm water; if very cold water is used, the steel will be too brittle. The temper should be drawn in the flame of a Bunsen burner, and the steel should be wiped frequently with an oily rag during the heating. If the reader is not familiar with the process of "drawing" the temper of tool steel, he had better get this done by an experienced workman.



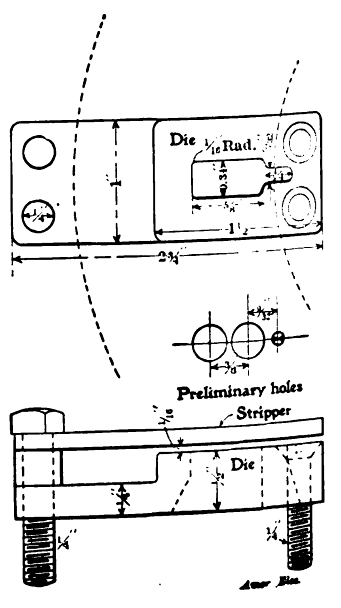


FIG. 3.—PUNCH AND DIE.—FIG. 4.

THE DIE.

The die is to be made of annealed steel, of the quality used for this class of work (any dealer will supply the proper quality if told what it is to be used for). The sketches show clearly the shape and dimensions of the die. The dotted-line arcs indicate the inner and outer edges of the stator disc when in position for punching. The hole in the die may be most readily cut by first drilling two holes 5-16 inch in diameter and one hole ⅛ in. in diameter along a straight line scribed on the face of the die block; the distances from center to center of these holes are stated in the supplementary sketch between the plan view and the side view of the die. Having drilled these three holes, the superfluous metal must be filed away slowly and very carefully until the desired shape of slot is obtained. Then the hole must be enlarged on the under side of the die block in order to give clearance for the small pieces punched out of the stator discs to free themselves.

The die is bolted to the bolster (which need not be made by the amateur, as the shop in which the punching is done will have bolsters from which an appropriate selection may be made) by means of two cap screws and two flat-head machine screws. The cap screws also hold the stripper plate, which is a rectangular steel plate ⅛ in. thick and of the same outline as the base of the die block; it must have a hole cut in it which will come directly over the hole in the die, but the hole in the stripper need not be accurately machined to the shape of the punch; it may be a simple rectangular aperture ⅜ in. wide and 1 in. long. After the hole in the die has been finished to fit snugly about the punch, which must touch *every part* of the wall of the die hole, the die is to be tempered. The remarks concerning the tempering of the punch apply also to the die.

STATOR CLAMPING PLATES AND ASSEMBLY.

The brass end plates are cast with the

slots in them, the sizes of the slots in these plates being a trifle full, as compared with the punched slots in the core discs. It will not do to use a simple brass ring of an internal diameter large enough to clear the slots in the core; the teeth between these slots must be clamped together tightly along with the body portion in order to reduce as far as possible the humming of the machine when in operation. In assembling the core discs between the brass end plates, the structure should be clamped together by means of two heavy cast-iron discs 8 inches in diameter and a 1½-in. bolt through the center; this work may be facilitated greatly by the use of ordinary iron clamps such as are found in all machine shops, applying these at points around the outer edge of the stator in order to even up the compression and assist the central clamping bolt. After the discs are drawn to position, the holes near the outer edge may be drilled; if the brass end plates have been made of a hard alloy, the top one will serve as a jig for the drill. In this event it should be drilled before assembling the core discs, but the under plate should be left undrilled; when the discs are assembled, the holes may be drilled clear through them and the under brass plate. A much safer plan, however, is to make a cast-iron jig plate and clamp the discs between it and a plain cast-iron plate for drilling; the brass end plates should be drilled by the same jig plate, but separately.

JOURNAL BRACKETS.

The four ⅜-in. bolts which hold the stator core together do not in this case serve to hold the journal brackets or end caps in place. Fig. 5 shows one of these end caps and Fig. 6 is an axial section through the center of it. The drawings require no explanation beyond saying that the caps are to be made of cast iron.

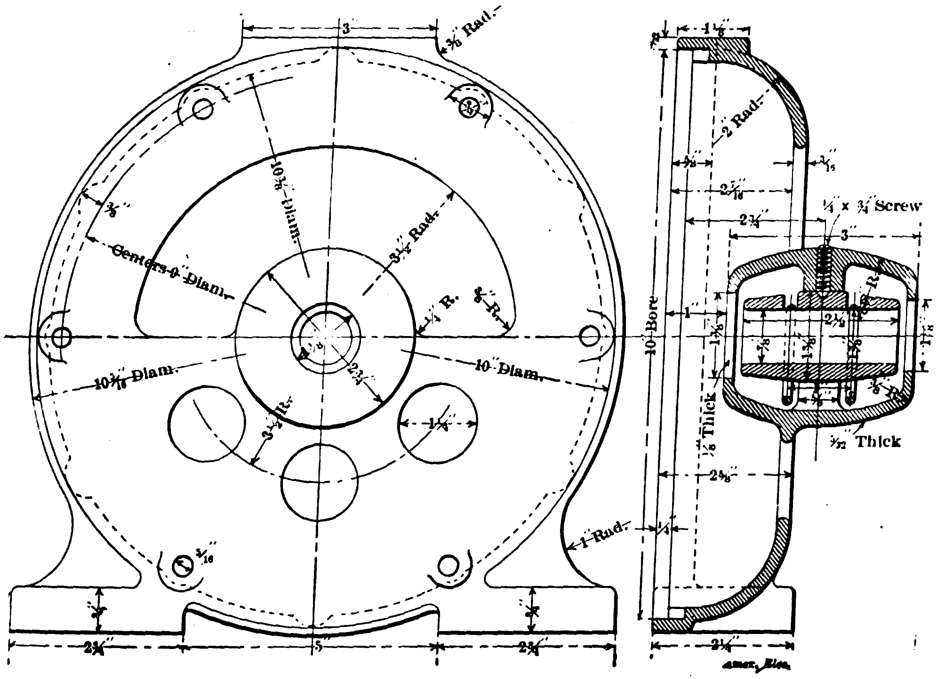


FIG. 5.—ELEVATION AND SECTIONAL VIEW OF ONE END CAP.—FIG. 6.

The journal sleeves shown in the engraving are of the self-aligning type, but if the reader is not very skillful at machine tool work it will be preferable to make them perfectly straight, making the outer diameter of the sleeves 1⅜ in. the whole length. No pulley has been shown, as this can be bought for less than it would cost an amateur to make it. The proper size is 4 or 4½ in. in diameter at the crown and 2½ in width of face.

The rotor is shown by Figs. 7 and 8. It consists of 270 discs of sheet steel 20 mils thick, clamped on the shaft between two cast-brass end plates, which also serve to connect the ends of the rotor conductors. There are 29 of these, each ⅜ in. in diameter and 7½ in. long; the holes in the rotor discs are 13-32 in. in diameter, and may be drilled with the aid of two cast-iron plates between which the discs are temporarily clamped, one of the cast-iron plates to be previously drilled so as to serve as a jig for the drill when the discs are drilled.

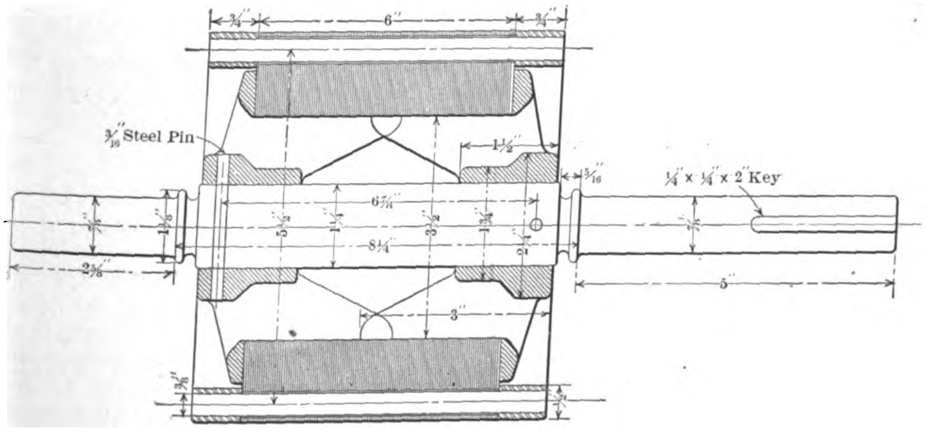


FIG. 7.—AXIAL SECTION OF ROTOR.

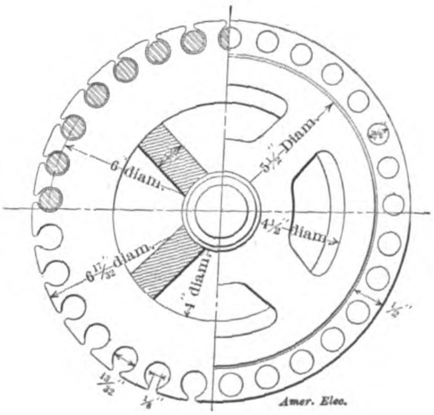


FIG. 8.—END VIEW OF ROTOR.

[In the August article the number of stator and rotor discs should have been 230 instead of 280.—EDITOR.]

STATOR WINDINGS.

After the stator is finished the slots and end surfaces of the core should be insulated by means of red rope paper 0.025 in. (25 mils) thick, which should be thoroughly varnished with shellac before being put in place. The main stator winding must not be put on until the starting winding is in place. This winding consists of six coils of No. 8 wire, each having 8 turns. Each of these coils should be wound into the proper slots over two blocks of wood (one at each end of the core) which will cause the coils to project 1 in. beyond the face of the stator end plates, as indicated in Fig. 9. After they are wound in place, these projecting ends are to be bent upward out of the way of the main coils, which must be wound in the slots between those of the starting winding. Fig. 10 indicates this bending upward of the starting coils, and also shows the slots into which they are to be wound. They are connected in series with each other, and the connections must be such that if direct

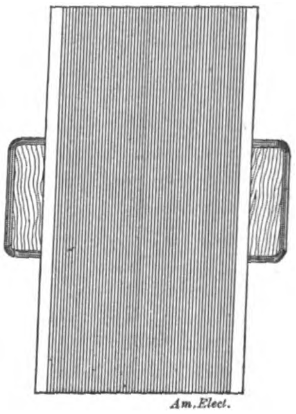


FIG. 9.—WINDING BLOCK.

current were passed through this winding it would produce alternate north and south poles within the six coils.

After the starting winding is in place and connected up, the six main coils should be wound into their slots; two thicknesses of varnished muslin must be laid over the exposed parts of the starting winding just before commencing the winding in of the main coils. These main coils consist each of 16 turns of No. 8 double cotton-covered wire, and each coil occupies four slots; they are to be wound in their slots as indicated by the elementary diagram, Fig. 10. The diagram shows only one turn in each slot, but the reader will of course understand that 8 turns are to be wound in the inner pair of slots, *I*, *I*, before any wire is wound in the outer pair, *II*, *II*, and that 8 more turns are then wound into these latter slots. The coils of the main winding, like those of the starting winding, must be connected up in series and in such wise that direct current passing through them would produce four magnetic poles of alternate polarity; north, south, north, south. It makes no difference what the relation is between the direction of the starting coils and that of the main coils; the terminals must be carried out to a three-pole, double-throw knife-blade switch, as indicated in Fig. 11, and if the connections at first made do not start the motor in the direction in which it is intended or desired to run, it may be reversed by merely reversing the leads from either the main winding or the starting winding, but not both.

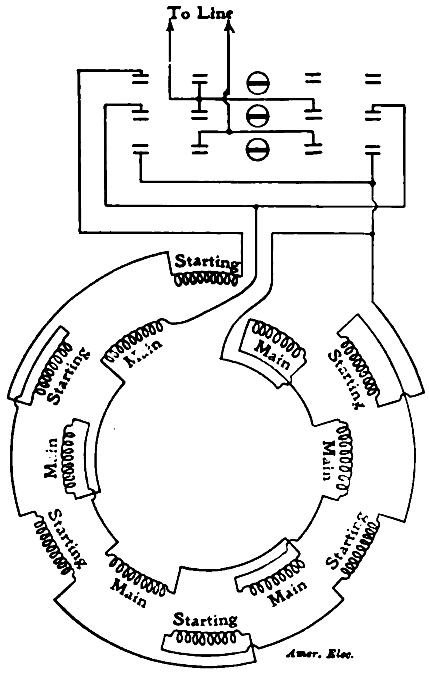


FIG. 11.—STATOR CONNECTIONS.

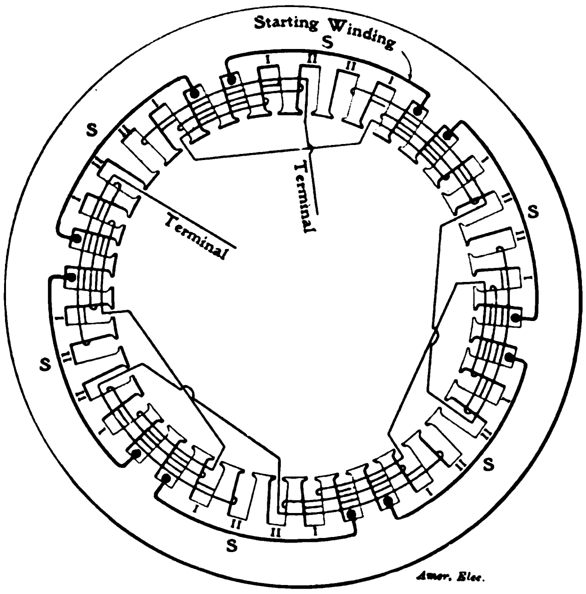


FIG. 10.—STATOR WINDING.

The switch should be mounted so that the throw is horizontal (unless an additional main switch is provided), in order that it may be left open without danger of accidentally closing by gravity. As the diagram is drawn, throwing the switch to the left puts in both windings, for starting up; when the machine attains something like normal speed, the switch should be thrown quickly to the other side, leaving only the main winding in circuit.

If the builder prefers to use simpler apparatus, two ordinary double-pole switches may be used, one for the main winding and one for the starting winding, but this arrangement has the slight disadvantage that the user may close one switch and leave it closed for an appreciable length of time before closing the other, which might overheat the winding thus thrown in alone, as the motor would not start up and the winding would be provided with a short-circuited secondary—the rotor conductors. The result would be similar in kind, though less in degree, to that obtained by short-circuiting the secondary terminals of an ordinary transformer with the primary connected to the supply mains. The motor should not be started with any load on it except the countershaft to which it is belted. Even with that it will be found advisable to give the belt a strong pull, to overcome standing friction, when the motor is thrown into circuit.

◆

OPERATION OF ROTARY CONVERTERS.

BY W. T. FERNANDEZ.

The advent of the rotary converter presented to the station operator a new, interesting and sometimes dangerous piece of apparatus, probably the most delicate piece of electrical apparatus produced for light and power service, combining in one structure the qualities of an induction motor, synchronous motor, direct-current, alternating-current and double-current generators. A rotary converter may be operated in any of these capacities with varying degrees of efficiency.

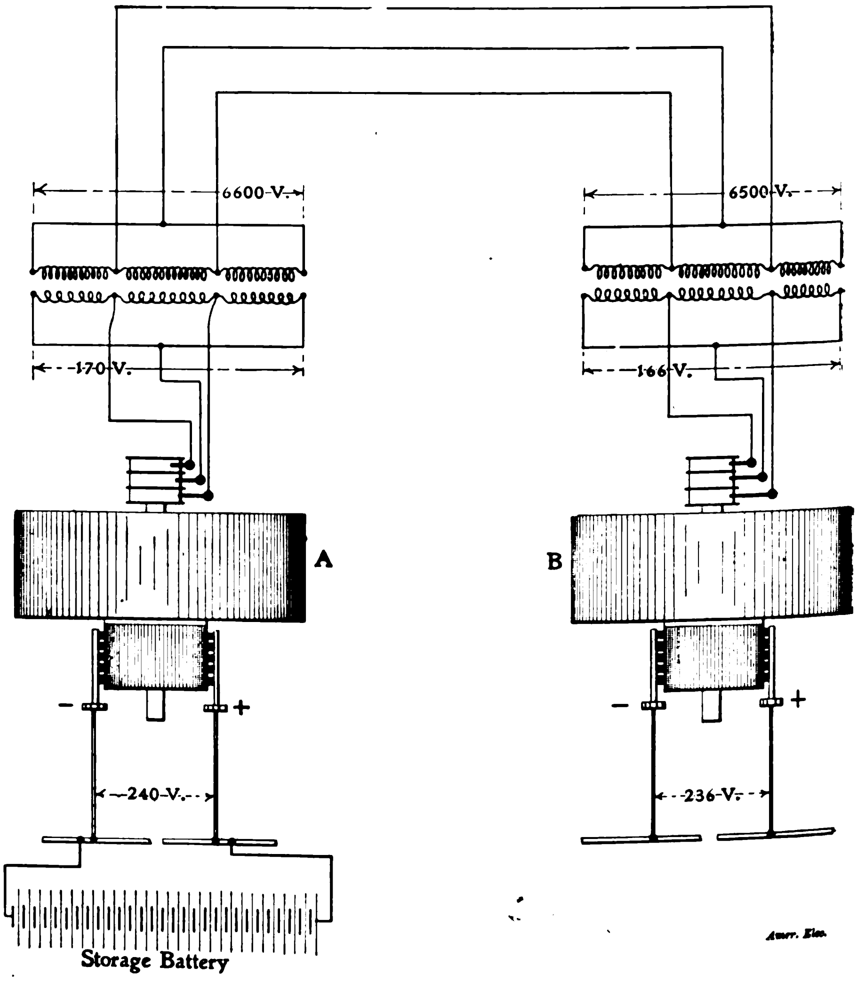


FIG. 1.—OPERATION OF ROTARY CONVERTERS.

The machines are built to operate on two, three or six-phase circuits, and consist of a set of stationary pole pieces surrounding an armature of the ordinary closed-coil type connected to a commutator in the regular manner and tapped at the other end at equidistant intervals by straps connected to suitable slip rings. The number of taps per ring being equal to the number of pairs of poles, the speed of the machine is equal to the cycles per minute divided by the number of pairs of poles.

The armature reaction, though slight, consists of two effects, a direct-current reaction similar to that of a direct-current generator, tending to twist the field flux in the direction of rotation and an alternating-current reaction similar to that of an induction motor, tending to twist the field flux in an opposite direction, providing the alternating currents are in phase with the impressed e.m.fs. The result of these reactions is a fairly even and uniform distribution of flux at all loads, permitting the direct-current brushes to be set permanently in the position where they will receive the commutated current from the coils when the coils are midway between the pole-pieces.

The operation and control of rotary converters operating in their natural capacity is the subject of this article, and as it requires greater care and judgment to run them from a secondary than from a prime mover, the writer will first consider the case of a 500-k.w. rotary driven by current from another 500-k.w. machine located in a station some miles distant from the receiving machine and connected to it by suitable transformers, cables, switches, etc. The connections are shown in the diagram. Converter, *A*, is running as a direct-current motor and sending power out from the alternating side to the low-tension windings of transformers, *a*, where it is stepped up to any desired voltage and delivered to the line connected to transformers, *b;* this group reduces the voltage again for delivery to the alternating side of rotary converter, *B*. Passing through the armature of this machine it is converted and delivered at the commutator as direct current.

The speed of the transmitting converter is controlled directly by the field excitation, just as though it were a separately-excited, direct-current motor, but it may be indirectly affected by conditions existing on the high tension lines or at the receiving end of the system. Any distortion of the phase angle of the line will affect the machines connected to it, the effect depending on the direction of the change; if it is in the direction of lead, the field flux of both machines will be increased and a corresponding decrease of speed will result; if it is in the direction of lag, an opposite effect is produced and the speed of both rotaries will increase. The variation of field flux is caused by the alternating currents being out of phase with the e.m.fs. in the line, and this condition may be brought about by improper adjustment of the field excitation of the converter at the receiving end, by an inductive load suddenly thrown on the system, or by a short-circuit on the transmission line.

It follows, therefore, that sudden changes of field excitation are to be avoided at either end of the line, because the machines, when operating as described, will instantly respond to any variation of the phase difference between the line current and e.m.f., and if the variation is excessive they may in a few seconds reach a destructive speed resulting in a serious wreck. If the operator at the receiving end increases the field excitation of his machine, a corresponding change of phase difference in the direction of lead (or less lag) will result, and the speed of both rotaries will decrease; if on the other hand he decreases the field strength at the receiving end, the consequent alteration of phase difference will be in the direction of lag (or less lead), and the speed of both machines will increase. The system tends to operate with as good a power factor as possible under existing conditions, hence the automatic regulation of speed to conform to any variation of the phase angle. The danger of an inductive load caused by too weak a field at the receiving end is evident and to be avoided for reasons of safety as well as economy when operating rotaries from a secondarv mover.

It will be noted from the characteristics of rotaries just described that an increase of inductance in the alternating-current circuit, causing the current to lag, will directly affect the speed of the machines on the system, and if excessive may cause a runaway. Therefore it is not a safe plan to start induction or synchronous motors or rotary converters from other rotary converters unless the transmitting machines are three or four times as large as the receiving machines, and are running under their strongest field excitation at the time, so that the leading effect of the strong fields will compensate for the lagging effect of the inductive load thrown on the system.

An open field circuit at either end of the line will cause a runaway if a single converter is operating on the transmitting end; but if a battery of rotaries is in use on that end the operator will probably have time to increase the excitation of his machines sufficiently to prevent the other machines on the system from attaining a dangerous speed.

If a prime mover is in parallel on the system, loaded or unloaded, the danger of a runaway is almost eliminated, for the reason that the rotaries are electrically locked to the prime mover, the speed controller of which is a steam governor; therefore the speed of the system can only be varied by the steam supply to the engine, and not by any electrical effect, with the exception of a short-circuit on the alternating-current lines, causing a sharp and excessive drop of the primary voltage. In such a case, if the rotaries are operating on a system supplied with direct current from engine-driven direct-current generators or from storage batteries, they will reverse and send out a volume of alternating current proportionate to the difference of voltage between the alternating and direct-current sides of the machine; the heavy lagging currents resulting from the short-circuit being out of phase with the e.m.f. delivered at the slip rings, will tend to race the machines at a dangerous speed.

The protective devices usually installed on a system of rotary converters will, as a rule, open the lines within a safe limit; but if they do not operate within five seconds it is advisable to clear the machines by hand. The safety devices are electrically operated, and are installed on both alternating and direct-current sides of the apparatus to be protected. They consist of an oil-break switch on the primary line in the sub-station, opened by either an overload or time limit relay, and a direct-current circuit-breaker operated in conjunction with a second time limit reverse-current relay on the direct-current side of the machine. A centrifugal device attached to the rotary converter shaft is used on some machines; an unsafe acceleration of speed causing it to open both the alternating and direct-current leads of the apparatus involved.

If the system is operating from a primary station, it will be found a safe plan to set the central station relays for about 100 per cent overload and two seconds time limit, the alternating-current relays at the sub-station for 75 per cent overload and 1½ seconds time limit, and the direct-current reverse-current relay for 25 per cent reverse load and 4 seconds time limit. If operating from secondary movers, adjustment for 75 per cent overload and two seconds time limit will be found practical on the alternating-current side. With safety devices set as described, a short-circuit on the line will be cleared at both ends in two seconds. Local trouble on the alternating side in the sub-station will be cleared from the line in 1½ seconds, and on the direct-current end 2½ seconds later. A momentary surge of the engines will not throw the sub-stations off, as all automatic circuit-breakers will hold for 1½ seconds.

The direct-current circuit-breakers, being set for two seconds longer than the line limit-switch, will cut out the machine if the local trouble continues after the line circuit-breakers have opened or failed to operate.

Clock-work and magnetic overload and relay devices do not clean themselves; they require blowing out, oiling and careful inspection at regular intervals to be operative when needed.

The conditions of the service in any particular plant determine the method of starting converters from a standstill. As mentioned in the early part of this article, a rotary may be operated either as a direct-current, induction or synchronous motor, and therefore may be started up in the same manner as any of these machines. The usual method is to start it from the direct-current side, as a direct-current motor, through a starting box which is cut out when the machine has attained sufficient speed to be cut in on the direct-current bus-bars; after the machine is switched from the starting box to the bus-bars, it is gradually brought to synchronism by weakening the field, and when in step, as indicated by lamps or a synchronizing voltmeter, it is cut in on the alternating-current side.

A second method is to speed up the machine, on the direct-current bus-bars to a speed a little above synchronism, then open the direct-current armature and field switches and close the alternating-current switches, when the rotary will pull into step. Care must be used with this method to open the direct-current armature switch first; if the field switch is opened first a dangerous speed may be reached before the armature switch can be pulled.

A third method is to start the machine from the alternating-current side. With the direct-current armature and field switches open, the alternating switches are closed, and the machine slowly builds up to synchronism; when a fair speed has been reached the field switch is closed and the machine is ready for load. On rotaries of over 100 kilowatts capacity, a special switch is mounted for closing the field circuit when starting in this manner; it is called a "break-up" switch, and its function is to divide the field winding into several sections, so that when the switch is opened the reactive kick is greatly reduced, and when it is closed uniform excitation of all the poles is obtained at the same instant.

A fourth method is to start the engine-driven alternator and the rotary from a standstill. With all switches closed between the alternator and the converter, the field circuit of the converter open and minimum excitation of generator fields, if the engine is started slowly the rotary will start up with the alternator; when the rotary armature has made several revolutions, the field switch should be closed, and when the engine has reached full speed, balance across the direct-current switches and switch in to the direct-current bus-bars.

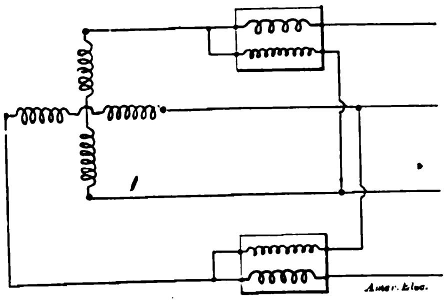


FIG. 2.—WATTMETERS ON TWO-PHASE CIRCUITS.

If a rotary is self-exciting it will sometimes, when started from the alternating side as described in the third and fourth methods, build up reversed on the direct-current side. This element of delay may be obviated by connecting a voltmeter to the direct-current terminals; as the machine builds up, the voltmeter needle will slowly swing from zero to a point well up on the scale, and if after the machine has reached a fair speed the field switch is closed at an instant when the needle is at the highest point of its swing, the machine will always build up with the correct polarity. The polarity of separately excited machines is fixed, of course, and there is no danger of building up reversed.

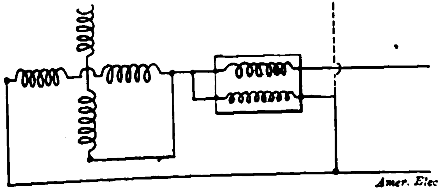


FIG. 4.—WATTMETER ON BALANCED TWO-PHASE SYSTEM.

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MEASUREMENT OF POWER IN ALTERNATING CURRENT CIRCUITS.

BY NATHANIEL R. CRAIGHILL.

The power in alternating-current circuits can be measured in various ways, but none of them is very satisfactory except the one which involves the use of the wattmeter. The others are all open to the objections that, in order to obtain any great degree of accuracy, about as much power is used in the auxiliary devices as in the power circuit, and also, that small errors in the observations lead to large ones in the results. The wattmeter method is the quickest and most accurate, and no computation is necessary, as is the case for the other methods, the watts being read directly from the instrument.

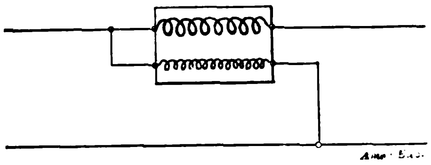

FIG. 1.—WATTMETER ON SINGLE-PHASE CIRCUIT.

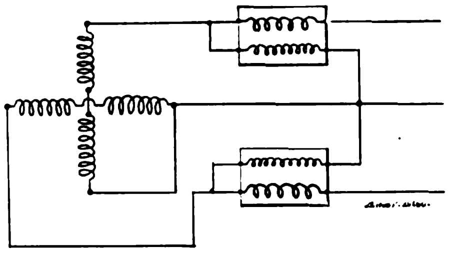

FIG. 3.—WATTMETERS ON TWO-PHASE SYSTEM.

The way in which a wattmeter is connected in order to measure the power of a single-phase circuit is shown in Fig. 1. The coarse wire coil, which is the series or current coil, is placed in series with the circuit: the fine wire coil, which is the pressure or potential coil, is connected across the circuit. The instrument, so connected, takes into account the lag or lead of the current and measures the true power of the circuit, the dial being so graduated that the pointer indicates true watts.

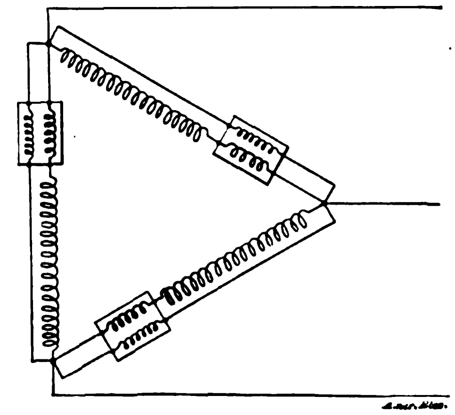

FIG. 5.—WATTMETERS ON THREE-PHASE DELTA-CONNECTED SYSTEM.

In a two-phase system with separate circuits, a wattmeter is placed in each circuit and simultaneous readings are taken. The sum of the readings of the two instruments gives the power in the system. Fig. 2 shows the proper arrangement of the wattmeters.

If only one instrument is available, it may be placed first in one circuit and then in the other, the sum of the two readings giving the total power, provided the load does not vary while the readings are being taken. For a perfectly balanced system, twice the reading of an instrument in one of the circuits gives the power, but it is not safe to depend upon such being the condition of affairs, so that this method is not absolutely reliable.

If the two-phase system has a common return for the two circuits, two wattmeters may be used connected as shown in Fig. 3. If the system is in perfect balance, and all the load connected between the outside wires and the common return, a single wattmeter can be used. It is connected as shown in Fig. 4; the series coil is placed in the wire which is common to both circuits, and readings are taken with the free end of the pressure coil connected first to one outside wire and then to the other, as shown by the full and dotted lines, the transfer being made as quickly as possible. The sum of the two readings gives the power in the system. However, this method is open to the same objection as the one explained in the preceding paragraph, which is that a condition of exact balance can not be relied upon; hence, the arrangement shown in Fig. 3 should be used whenever possible.

In a three-phase delta-connected system, if the current coils of the wattmeters can be inserted into the load circuits as shown in Fig. 5, three instruments may be used. The power in the circuit is the sum of the readings of the three wattmeters. If the system is exactly balanced, three times the reading of one instrument will give the power. If, however, the wattmeters cannot be inserted into the circuits of the system in the manner shown, an artificial neutral point may be created by connecting together three non-inductive resistances at one end and connecting the other ends respectively to the three corners of the circuit. The arrangement of the connections is shown in Fig. 6. If E is the pressure in one circuit coil, the pressure between the neutral point and each corner is $\frac{E}{\sqrt{3}}$; a wattmeter having

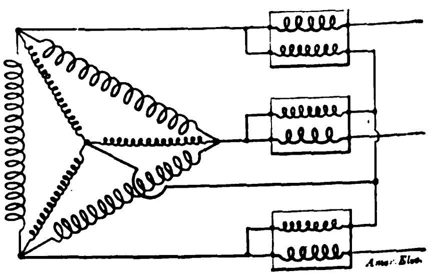

FIG. 6.—WATTMETERS ON THREE-PHASE DELTA-CONNECTED SYSTEM.

its series coil in the circuit wire and the free end of the pressure coil connected to the neutral point, as shown in the figure, will, if *I* is the current in each circuit coil, have a current to $\sqrt{3}\,I$ passing the series coil and a pressure equal to $\frac{E}{\sqrt{3}}$ between the ends of the pressure coil. The reading of the instrument will be, if ϕ is the angle by which the current lags behind the e.m.f.

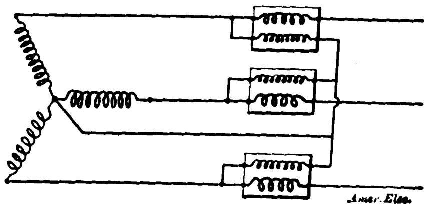

FIG. 7.—WATTMETERS ON THREE-PHASE SYSTEM.

$$\frac{\sqrt{3}\,EI\cos\phi}{\sqrt{3}} = EI\cos\phi$$

which is the power in one coil. The sum of the readings of the three instruments gives the total power in the circuit irrespective of the condition of balance. In creating an artificial neutral point, the equal non-inductive resistances must always be so small compared with the resistances of the potential coils of the wattmeters that there will be no disturbance of the potential of the neutral point.

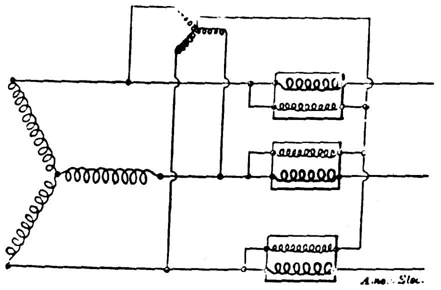

FIG. 8.—WATTMETERS ON THREE-PHASE SYSTEM.

For a three-phase, Y-connected system, three wattmeters may be used. If the neutral point of the system is accessible, they should be connected as shown in Fig. 7. If it is not, an artificial neutral point may be created in precisely the same manner as was explained for the delta-connected system. Fig 8 shows the arrangement of the instruments for this case. Using the same notation as before, the current in the series coil of each instrument is *I* and the pressure between the terminals of the potential coil is *E*; hence the reading of each instrument will be *EI* cos ϕ, which is the power of one circuit coil. Therefore the sum of the readings of the three instruments gives the power of the circuit. If the system is balanced, the total power is three times the reading of one instrument.

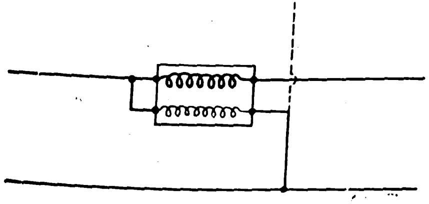

FIG. 10.—WATTMETER ON BALANCED THREE-PHASE SYSTEM.

Two wattmeters connected as shown in Fig. 9 will give by the algebraic sum of their readings the power in either a Y-connected or a delta-connected system. If the power factor is less than 0.50 (in which case the lag of the current is greater than 60°), one instrument will give a negative reading on account of the relation between the current in the pressure coil and that in the current coil, and the power will be found by subtracting the reading of one instrument from that of the other. With low power factors, it is frequently difficult to tell whether the smaller readings are negative or not. When there is this doubt, a separate load of lamps (the power factor of which is 1) should be connected up to the meters, and the connections so arranged that both instruments deflect in the proper direction. Then they should be again connected to the load to be measured; if the instruments still deflect in the right direction, the sum of the readings is to be taken, but if it is necessary to reverse the connections of one of the instruments in order to make it deflect in the right direction, the difference of the readings must be taken in order to get the power. These statements can be verified mathematically, but this proof is beyond the scope of this article.

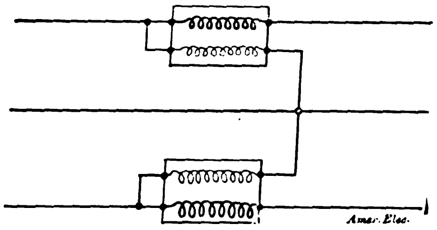

FIG. 9.—WATTMETERS ON THREE-PHASE SYSTEM.

In a balanced three-phase circuit, one wattmeter can be used to measure the power by inserting the series coil in one main and connecting the free end of the potential coil successively to the other two mains. The power is the sum of the two readings of the instrument. The arrangement of the wattmeter connections is shown in Fig. 10. The full and dotted lines show the two connections for the potential coil.

With the exception of the two-phase system, it is possible to measure the power in any system of *n* phases and *n* wires, irrespective of balance, by means of *n*-1 wattmeters. The method is similar to the one using two instruments for the three-phase system. The series coils of the wattmeters are connected one in each of *n*-1 of the circuit wires and the free ends of the potential coils are all connected to the remaining wire. Some of the instruments will read negatively, so care must be taken to make all of the original connections in the same sense; then the readings of these instruments the connections of which have to be reversed in order that they shall give deflections in the right direction, should be added together, and their sum subtracted from the sum of the readings of the other instruments.

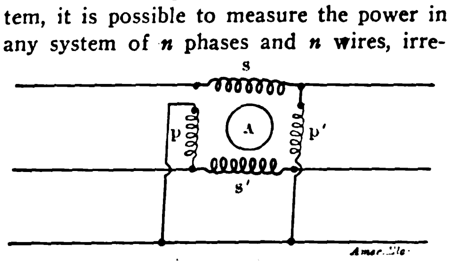

FIG. 11.—COMBINATION METER ON THREE-PHASE SYSTEM.

With the exception of the two-phase system, the power in any balanced polyphase system can be measured by one wattmeter, the current coil of which is connected in one of the mains and the pressure coil between the main and the neutral point of the system, creating one if necessary by connecting together the ends of equal non-inductive resistances and connecting one of the free ends to each of the other mains of the circuit.

Instead of two meters, one combination meter of the induction type may be used to measure the power of a three-phase system. It consists of two single-phase meters so arranged that the power is recorded on a single dial, as shown diagrammatically in Fig. 11; *A* is a closed secondary or armature placed so as to be acted upon inductively by the series coils, *s*, *s'*, and shunt coils, *p*, *p'*, which are displaced in mechanical phase 90° in relation to each other. The arrangement of connections here shown is suitable for either a Y or a delta-connected system.

In order to measure the power in a monocyclic circuit, the method of procedure is the same as for an unbalanced three-phase system. With the ordinary single-phase meters, one is connected in each outside wire and the free ends of the potential coils to the common return. The combination induction meter may also be used for this case. It is connected in circuit in the same manner as for a three-phase system, as shown in Fig. 11.

◆

High-Speed Traction Experiments.—The Berlin Union Electric Company will shortly start some new electric traction experiments with high speeds on the Johannisthal-Spindlersfelde suburban line, the State Railway Department having made arrangements with the Union Company to the effect that these trials are to be finished within two years. The electric equipment of the line will be supplied from the Ober-Spree power station, and a special track will, of course, be provided. The State Railway Department has supplied two six-axle coaches fitted with compressed-air brakes, these coaches having been transformed into motor cars by the Union Company. These cars are to be run at first with single-phase alternating current at a tension of 6,000 volts. By the use of a new single-phase motor it is intended rendering the supply of current to long-distance railways as simple as is now the case with urban railways. In the case of the motor-car trials proving satisfactory, trial trains are to be run, each train including three trailing coaches.

THE PRACTICAL STORAGE BATTERY OPERATION.

BY H. P. LIVERSIDGE.

Storage batteries have recently undergone such radical changes in point of construction that the modern engineer is forced to admit that the battery is an actual necessity to the successful operation of electrical generating systems of certain classes.

Notwithstanding this fact, one repeatedly hears the same old cry, that the battery needs more repairs than the whole station and is not worth the room it takes up. If one is inquisitive and goes a trifle further, and makes inquiries concerning the nature of these troubles, usually one hears the familiar tale of played out positives or buckled negatives and a dozen or more kindred battery ills. On the other hand, there is not a battery manufacturer who cannot give column after column of figures relating to the life and efficiency of his type of cell, results which are not mere makeups, but taken from actual tests of the battery manufactured. And then, in rebuttal one hears the argument from battery users that laboratory tests show nothing about the operation of a cell when put in actual service. There is no reason in the world why a storage battery, if properly installed, cannot give results which will come very close to those obtained from so-called laboratory tests.

A station superintendent would hardly think of placing a steam engineer in charge of the electrical end of a plant unless the man had some previous knowledge of the subject, and yet he will think nothing of installing a battery, costing, perhaps, half as much as the entire station machinery, and trusting the care of it to some inexperienced dynamo attendant. As usual, the man knows just about as little concerning the actual operation of the battery as he does about the chemical reactions taking place in the cell. No one expects him to know much about the latter, and the station superintendent acts as if it were not necessary for him to know anything about the former. Of course, he is told to stop charging when the cells "bubble" and pour in water when the plates are uncovered. Perhaps he is given instructions about hydrometer readings and treatment of low cells, but this is generally the extent of his knowledge. One would hardly think of trusting the care and operation of generating machinery to similarly inexperienced hands; and yet the battery, a far more delicate piece of apparatus, is often subjected to the severest wear and tear of the station, with hardly any attention, except dumping in the water and charging until it "bubbles."

A storage battery is somewhat like a dray horse; you can give it almost any amount of hard work, so long as you are careful to give it the proper attention to keep it in a healthy condition. Probably no point in the operation of a storage battery deserves closer attention than proper charging. It is a deplorable state of affairs, but nevertheless a fact, that the greater part of the troubles found in storage cells can be traced directly to this cause. Considerable care, therefore, should be exercised on this point, especially in the matter of proper charging rate and point of cut-off. The current in charging is dependent, not only on the size of cell, but on the method in charging. There are in general use three methods for charging a battery; at constant wattage; at constant voltage, and at constant current. The first two methods present several objectionable features when used in station work, so that the prevalent practice has been to charge with a constant current. In using this method, the normal charging current should not exceed the eight-hour discharge rating of the cell. If, for example, the capacity of the cell was rated at 4000 ampere-hours for the eight-hour discharge, the normal charging current would be 500 amperes. In cases of emergency a current of 15 to 20 per cent in excess of normal charging current can be used during the earlier part of the charge. Care must be taken, however, to reduce this current to the normal charging rate before the cells show signs of violent gassing.

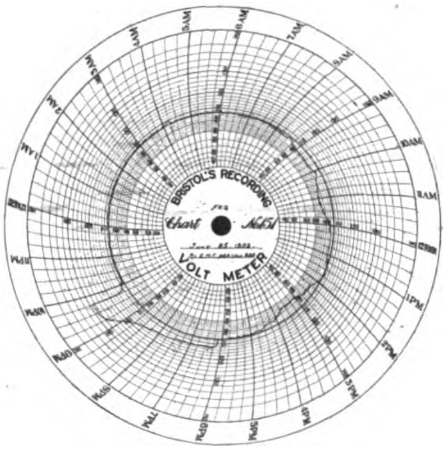

FIG. 1.—RECORDING VOLTMETER CHART.

In determining the proper point of cut-off, there are several indications which help to show when the cells are charged. It is not enough, however, to know that the battery is charged; one must also know the proper point to stop the charge. Only too often a charge is continued until the operator has satisfied himself beyond a doubt that the battery is entirely "filled." The fact that the cells are greatly overcharged does not seem to be appreciated by him.

A complete charge, which in general should not exceed the previous discharge more than 10 or 12 per cent, is determined by the voltage and specific gravity reaching a maximum, also by the amount of gassing and color of the plates. The first two, however, are the chief guides. The amount of gassing and color of the plates are simply useful in determining whether or not the battery is charged, and cannot be used to give any idea of the proper cut-off. During the final part of the charge gas will be given off freely from the cells. The plates will have reached a deep chocolate brown, for the positives, and a light slate or gray color for the negatives.

As has been stated previously, the maximum readings of voltage and specific gravity are the only accurate criteria for determining the exact point of cut-off. Do not make the mistake, however, of supposing the maximum value to be any certain fixed reading. This is an error which is only too often made. Voltage readings at the end of charge vary considerably and are dependent chiefly upon the age of the plates, temperature of the electrolyte and strength of charging current.

When first installed, a storage battery, on normal charge and at a temperature of 70° Fahrenheit, will give 2.5 to 2.54 volts. As the battery ages this value may drop to perhaps as low as 2.4 volts on normal charge. Temperature changes of the electrolyte tend to decrease the maximum charging voltage for any rise above normal (70° F.) and correspondingly increase the voltage for all temperatures below normal.

A charging rate in excess of normal current will cause a higher voltage at the completion of the charge and, conversely, a lower voltage if the charging rate is less than normal current.

Specific gravity readings are not subject to as great variations as the voltage. During every charge some of the acid is sprayed out and with the continual addition of water the electrolyte is gradually weakened. Another cause for the gradual weakening of the acid is the accumulation of sediment in the bottom of the tank as the life of the cell increases. This material tends to absorb some of the acid, which chemically combines with it and is thus prevented from going back into the solution.

Care must be taken, therefore, to stop the charge of a battery when the maximum readings of voltage and specific gravity have been reached. When it is inconvenient to take both sets of readings the voltage may be used alone as an indication of complete charge. In fact, for practical station work, the voltage reading, if properly taken, is the easiest and safest means of telling when the charge is completed. Specific gravity readings must not be omitted, however, and should be taken a short time after the completion of the charge. This will enable the operator to keep a close check on the condition of the individual cells in the battery, as it occasionally happens, due to some local trouble, that one or more of the cells may not receive a full charge.

In regular operation a battery can be considered completely charged when, with constant current flowing, the voltage reading has remained constant for a period not less than fifteen minutes.

In order that the voltage may be easily and accurately read, the use of recording voltmeters is especially recommended. The instrument should preferably be mounted on the switchboard and connected in such a manner as to indicate the complete range in voltage of the battery, both on charge and discharge. By its use the operator is enabled to note accurately the progress of charge and discharge and thus determine the proper time to stop either. In addition to these points, the meter furnishes a permanent record of the operation of the battery.

Fig. 1 shows very clearly the application of the recording chart for indicating the operation of a battery. The voltmeter in this particular case, was connected across 51 cells of a battery operating on an incandescent lighting system. The normal charging current was used and the maximum e.m.f. of 128.8 volts gives approximately 2.52 volts per cell at the end of the charge. The charge was started at 6:10 p. m. and at 9:30 p. m. the maximum voltage was reached. From 9:30 to 9:45 the reading is constant, thus indicating complete charge and the proper point of cut-off. As shown by the chart also, the battery was discharging from 8:35 a. m. until 11:50 a. m., and again from 2:00 until 4:30 p. m. During the remainder of the twenty-four hours the battery floated on the system, taking care of any slight fluctuations in the station load.

During the time the battery is floating on the system considerable care should be exercised in order that the charge and discharges may be kept as small as possible. This point applies particularly to batteries used on lighting circuits, so provided with end-cell regulation that the charge and discharge can be controlled as desired, irrespective of the load variations on the system. Too much stress cannot be laid on this point, as it is a common occurrence for batteries to receive considerable overcharge while, supposedly, lying dormant on the system.

Practical operation has shown that, in order for a battery to give the best results, the average e.m.f. per cell for any discharge and corresponding charge, or series of discharges and complete charges, should be, approximately, 2.09 volts. This value is for cells in good condition and will rise slightly as the battery ages. Under normal conditions, therefore, an e.m.f. exceeding this average would indicate an overcharge, and less than this average, an undercharge.

In contrast to Fig. 1, the charge of Fig. 2 shows very clearly the effect of overcharging during the period when the battery is supposed to be floating on the system. In Fig. 2, this period extended from 2:50 p. m. to 7:15 a. m. From the beginning of the first discharge at 7:15 a. m. until the end of the charge at 2:50 p. m., the average e.m.f., as shown by the dotted line, is 106.7, or 2.09 volts per cell. For the twenty-four hours, however, the average e.m.f. is 108.7, or 2.13 volts per cell, thus indicating a considerable overcharge, due entirely to the small charging current allowed to flow while the battery floated on the system.

Practically the same indications which help to determine the proper charge serve in reverse order, to show the proper discharge of a battery. In discharging a battery there are two points which should always receive especial attention; namely, the rate of discharge and the proper point of cut-off. All cells are designed to give a certain maximum output for some specified length of time; in general practice this maximum is the amount of current which the battery will safely deliver for one hour. When it can possibly be avoided this value should never be exceeded. An excessive discharge rate is sure to weaken the plates and in some cases cause the elements to buckle so badly as to short-circuit the entire cell. However, in station work, especially on incandescent lighting systems, the discharge may reach several times this value for a few minutes, due to some accident to the line or generating machinery.

As the discharge of a cell continues, the voltage and specific gravity will gradually fall; the color of the plates will also change, the positive to a yellowish brown, while the negative will darken considerably. The first two indications are the only practical guides in determining the proper point of cut-off. Both the specific gravity and voltage readings, however, will vary according to several conditions, and, as complete discharge is only determined by some certain fixed value, dependent on these conditions, care should be taken that they are not neglected in ascertaining the point of complete discharge.

The fall in specific gravity depends chiefly upon the proportion of electrolyte in the cell. If the proportion of solution is in excess of the normal amount, the drop in specific gravity will be decreased and, conversely, less electrolyte than normal will cause an increased drop in specific gravity. Under ordinary conditions, if the cell contains the full number of plates, with no sediment in the bottom of the tanks, and the acid covering the tops of the plates about one-half inch, the fall in specific gravity should not exceed 35 points. If, for example, the specific gravity at the commencement of the discharge was 1.205, the final reading would be 1.170.

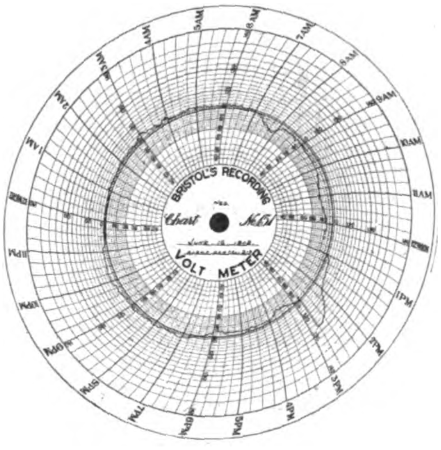

FIG. 2.—RECORDING VOLTMETER CHART.

The e.m.f. at the end of the discharge is dependent chiefly upon the rate of current flowing. Battery manufacturers recommend that a cell should not be discharged below 1.7 volts, when discharging at the normal rate. With the maximum discharge current flowing, this value may fall to 1.6 volts without materially damaging the battery. For practical work 1.7 volts per cell is as low as safe operation will permit. When a cell has reached this point, any further continuation of the discharge will cause a very rapid falling off in voltage. Immediately upon the completion of a heavy discharge the battery should be put on charge. Under no circumstances should a battery be allowed to stand discharged as the plates will immediately begin to sulphate, causing no end of trouble, if allowed to continue.

The storage battery is no exception to the general class of electrical apparatus, in the matter of repairs, so that troubles of one kind or another must be expected. It is rarely the case that any trouble arises which will damage the entire battery. In any such event, the cause is usually apparent and needs no further explanation. Frequently, however, individual cells in a series will require especial attention, due to some local trouble which may develop. We will therefore consider in this connection the most probable cases which are likely to arise in practical operation.

When a cell shows signs of trouble, one should never guess at the cause and then take the chance on the remedy applied. This is only too often the method employed and the usual results are obvious. The surest indication of a "sick" cell, is the specific gravity reading. There are exceedingly few ills which affect storage batteries that cannot be immediately detected by hydrometer readings. It is important, therefore, that frequent readings be taken of the entire battery in order that any trouble may be detected and remedied, before damage is caused to the cell. These readings should preferably be taken after every complete charge.

In ordinary practice, battery troubles can usually be traced to weakened electrolyte, insufficient charge, short-circuits, grounds or worn-out plates. Weakened electrolyte is usually due to excessive gassing during a charge, though cases have arisen where an individual cell has been flooded with water from a leaking waterpipe. Under ordinary operating conditions the amount of acid lost by gassing ought not to lower the specific gravity more than 5 points during a year. This value will be materially increased if an excessive charging rate or overcharge is used. A low specific gravity will not appreciably effect the maximum voltage of the cell on charge, provided the drop is not over 15 or 20 points. If the normal e.m.f. is reached on the succeeding charge the trouble may safely be laid to a weakened electrolyte. Acid should then be added until the density is brought to the normal value. It is advisable also that its specific gravity should be at least 1.4 in order that the electrolyte may be raised to the proper density without necessitating an excessive addition of acid.

Insufficient charging of an individual cell is a condition which most frequently occurs in batteries provided with end cell regulation. It very often happens that an end cell is discharged in series with the main battery, and then missed on the succeeding charge. Sometimes, also, a battery may be partly discharged on a certain number of cells and then floated on a light charge with a lower number of cells in series. On the regular charge, therefore, the lower number of cells will have been completely charged before the few end cells are charged. A voltmeter reading taken from the individual cell will not show a maximum with the main battery, thus indicating an incomplete charge.

One of the evil effects of undercharging is the formation of lead sulphate on the surface of the active material. If allowed to continue, this sulphate forms a hard shell which acts as an insulator and thus prevents the cell from working properly. If the action has not gone too far, an exceedingly long charge at a low current density will usually loosen the scale. If it cannot be removed in this manner the plates should be cut out and scrubbed until the sulphate is entirely removed. This is not advised, however, except as a last resort.

The easiest method of fully charging a single cell without overcharging the entire battery, is to discharge the battery on a lower number of cells and then charge with the low cell in circuit. If it is found necessary to give an additional charge to any cell in the main battery the entire series must be overcharged. Some stations have recourse to a small charging set so designed that it can be wheeled to the particular cell and connected so as to charge it separately. This plan is most satisfactory, but, of course, necessitates the use of a separate charging dynamo.

Short-circuits are usually caused by buckled plates, sediment in the bottom of the tank, or foreign substances between the grids. A short-circuit can immediately be detected by the voltmeter, when placed across the terminals of the cell, giving a zero reading. Sometimes the short-circuit may be more correctly regarded as a leak, in which case the e.m.f. may be any fraction of a volt above zero.

As previously stated, a buckled plate is usually caused by a continued excessive overcharge or a heavy discharge. If the plates are not badly damaged they can be driven apart with wooden wedges and operated with a fair degree of safety. In cases where they are burned together the plates must be cut out and replaced by new grids.

As the life of the cell increases, the depth of sediment in the bottom of the tank gradually rises until the bottoms of the plates are entirely submerged in the deposit. This will either completely short-circuit the cell or cause excessive leakage. The usual method of removing the deposit is to empty the acid and then scrape the sediment from the bottom of the tank. A more satisfactory plan is to draw off the acid, fill the cell with water, mix the sediment thoroughly with the water and then pump out the solution with a small centrifugal pump. It is usually necessary to go through this procedure several times before the tank is entirely free from the deposit.

Any foreign substances which may accidentally fall into the battery can usually be pushed down between the plates until it drops to the bottom of the tank. A long wooden paddle, preferably made of ash, about ¼ inch thick and 2 inches wide will be found very convenient for running between the plates.

Grounds are usually caused by leaky cells. The acid gradually trickles out from the sides or bottom of the tanks and finally forms an electrical connection with the earth. A film of acid spray on the external copper conductors is often a cause of grounds in a battery room. A good plan is to wipe all the conductors and connections with raw linseed oil at least once every week. If the gassing is not excessive the action on the conductors will usually be entirely checked. Any fairly heavy ground will be detected by a gradual fall in the voltage and specific gravity of the battery during the period when it is lying dormant on the line.

There will come a time in the life of every battery when the plates may be said to have reached their limit; sometimes it is the positive, sometimes the negative, but usually it is the positive that gives out the quicker. A negative will often outlast two or three positive plates. Trouble due to worn-out plates is usually indicated by an exceedingly short discharge and a reduced maximum voltage on charge. The maximum charging voltage, as stated previously, will often be as low as 2.4 volts per cell.

It is generally a simple matter to determine whether or not the trouble is due to worn out plates. The case presents a few difficulties, however, when the question arises as to just where the trouble lies. It sometimes happens that both sets of plates wear out together; oftener, however, one set will give out long before the other. The simplest and most satisfactory method of determining the condition of the plates is by the use of cadmium readings. This method, I do not believe, is very commonly used in battery work, so that the remainder of the article will be devoted to a brief description of this test.

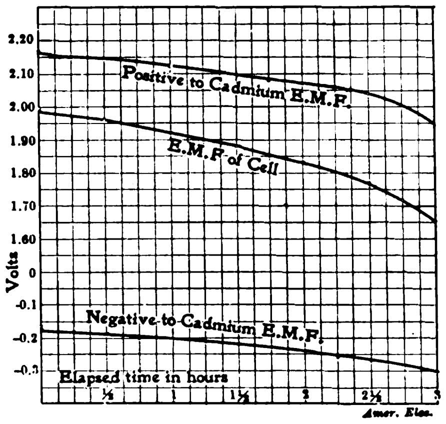

FIG. 3.—STORAGE BATTERY CURVES.

A rod of cadmium is used and this should be long enough to cover at least six plates, when placed at right angles to the tops of the plates. Commercial cadmium is usually made in rods ¼ inch in diameter, so that it is preferable to use this thickness in testing. The cadmium should be encased in a rubber tube, perforated, so as to allow the acid to reach it easily from all sides, but so protected as not to permit electrical connection with either the positive or negative plates. The rod should be laid across the tops of the plates, at right angles to them, and so placed as to cover an equal number of positive and negative grids. Care must be taken that the cadmium is completely submerged in the electrolyte. A low reading voltmeter should then be arranged so that readings can easily be taken between the positive and negative terminals of the cell and the cadmium pole, and also between the positive and negative plates of the cell. The cell should then be gradually discharged and readings taken of the voltage between positive and negative, positive and cadmium and negative and cadmium.

If the cell is in normal condition and the e.m.f. has dropped to 1.65 volts at the end of discharge, the e.m.f. from positive to cadmium should read 1.95 volts, and from negative to cadmium —0.3 volt. These values are not exactly alike for all cells, but they are approximately correct for the standard types of power batteries now in use.

Fig. 3 shows the action of the positive and negative plates under normal discharge conditions. If, however, either set of plates is worn out, the e.m.f. of the worn out element will not follow a discharge curve similar to Fig. 3. As a consequence, one curve will reach the danger limit, 1.95 for the positive and —0.3 for the negative, long before the other curve indicates a complete discharge, or, in other words, has reached the lowest safe cadmium reading. The cell e.m.f., taken between the positive and negative terminals, should at all times equal the arithmetical sum of the positive and negative cadmium voltages. This can readily be seen by an examination of the curves in Fig. 3.

Suppose, for example, the positive cadmium reached 1.95 volts at the end of one and one-half hours' continuous discharge; if the negative plate was in good condition the negative cadmium curve would indicate —0.22, approximately. The sum of these two readings would then be equal to the cell e.m.f., or 1.78 volts. In this case, if the e.m.f. were alone taken as a guide, the curve would indicate that the cell had not yet reached its complete discharge. The positive cadmium curve, however, would show conclusively that the positive plates would be worked beyond the safe limit if the discharge were continued. One can readily see, therefore, that this test is an exceedingly important one in determining the action of each set of plates.

If at all possible cadmium readings should be taken once every month. By so doing, any unevenness in the discharge of either set of plates can at once be detected and remedied before the weakened set has been further damaged due to repeated discharges below the lowest point of cut-off—not necessarily anywhere near the lowest point of cut-off of the cell.

In conclusion it might be said that careful and intelligent attention are the chief requisites for the successful operation of a battery. The writer, however, does not wish to create the impression that battery operation requires any superior skill or education; but rather desires to emphasize the fact that the storage battery deserves at least the same intelligent care and attention that is demanded in the practical operation of all classes of electrical apparatus.

Lessons in Practical Electricity

DIRECT-CURRENT MEASURING INSTRUMENTS.

In previous Lessons frequent references have been made to e.m.f. and current values, but the means of determining these values have not thus far been mentioned. For this purpose instruments are used which give indications on a scale by means of a hand or pointer, volts being indicated if it is e.m.f. that is being measured, or amperes if it is current. An instrument for measuring e.m.f. is called a "voltmeter," and one for measuring current, an "ammeter" (which is a contraction of amperemeter). Both classes of instruments depend for their operation upon either the magnetic or heating effect of the electric current, the mechanical and electrical arrangement being the same for both an ammeter and a voltmeter of a given type.

Voltmeters and ammeters may be divided into three general classes, namely, magnetic-needle instruments, electromagnetic instruments, and hot-wire instruments. The arrangement of the working parts of a voltmeter of the magnetic-needle principle is shown in Fig. 1. A soft iron needle, *n*, is pivoted inside of a coil, *c*, of very fine wire, and is held out of line with the axis of the coil by means of a permanent magnet, *m*, when the instrument is idle. In this position, a pointer, *p*, which is attached to the needle stands at the zero mark of the scale, *s*. If a current is passed through the coil, magnetic lines of force are set up in its centre, which tend to pull the needle into line with them, and therefore, with the axis of the coil. This pull is resisted by the permanent magnet, *m*, and the amount of deflection of the needle from the zero position depends upon the strength of the current passing through the coil. As the resistance of the instrument is constant, the current in the coil is directly proportional to the e.m.f., which causes it to flow; and, therefore, the deflection of the needle really depends upon the e.m.f. at the coil terminals, so that if the scale is properly marked, the pointer will indicate volts.

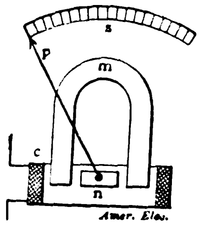

FIG. 1.

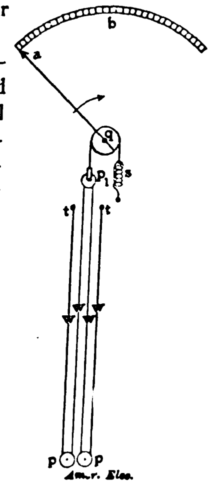

FIG. 3.

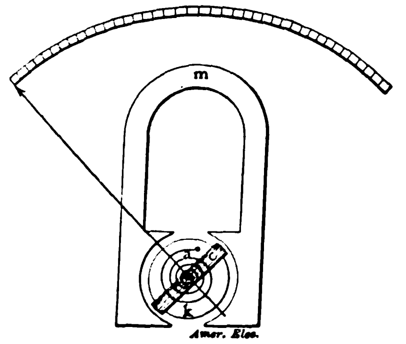

FIG. 2.—ELECTROMAGNETIC VOLTMETER.

Fig. 2 illustrates the principle of a voltmeter of the electromagnetic type. In this case, the coil, *c*, is pivoted between the poles of a permanent magnet, *m*, and moves between them and a fixed soft iron core, *k*. It is held in normal position by two spiral springs, *a*, one above the core, *k*, and one below it, which also serve the purpose of making electrical connections with the coil, *c*. When a current passes through the coil, magnetic lines are set up in it which are in direction at an angle to those passing from one pole of the permanent magnet to the other. The lines of force, which formerly passed from one pole of the magnet to the other by straight lines or by short curved ones, are stretched on account of the field produced by the current in the coil; and, in trying to shorten themselves, tend to twist the coil through an angle. This tendency to move is resisted by the two spiral springs. In precisely the same way, as was explained in the preceding paragraph, the deflection of the coil, *c*, depends upon the current in the coil and, as the resistance is constant, upon the e.m.f. causing the flow of current. Hence, if a pointer is attached to the coil, it will indicate volts on a properly marked scale.

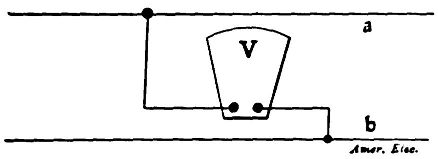

FIG. 4.—VOLTMETER CONNECTIONS.

If an instrument of either class is to be used as an ammeter, the coil must be made of very heavy wire, if it is to carry the full current; or else the coil is made of fine wire and the instrument is connected in parallel with a low-resistance shunt, as will be explained later, so that only a fraction of the whole circuit current passes through it. In both cases, however, the scale is so graduated that the pointer indicates the whole current of the circuit.

Hot-wire instruments depend for their action upon two principles, namely, that a conductor is heated by a current flowing through it, and that the length of a wire increases when it is heated. The method of arrangement and operation is shown diagrammatically in Fig. 3. A fine wire, *w*, of high resistance is connected to the two terminals, *t*, *t*, which are rigidly fastened to the frame of the instrument. The wire passes around the three pulleys, *p*, *p*, and p_1, two of which, *p*, *p*, are also rigidly fastened to the frame, the third, p_1, being free to move up and down. It is fastened by a metal band to the pulley, *q*, which is fastened to the frame. A spring, *s*, one end of which is fastened to the frame and the other to the pulley, *q*, tends to rotate the pulley in the direction of the arrow; this tendency to rotate is resisted by the wire, *w*, and when no current is flowing, the pulley is in such a position that the pointer, *a*, attached to it indicates zero on the scale, *b*. When current passes through the wire, it becomes longer under the heating effect of the current, and allows the spring to move the pointer over the scale, which may be marked so as to indicate either volts or amperes, according to whether the instrument is to be used as a voltmeter or ammeter. An ammeter of this class is always used in parallel with a shunt of low resistance, as it would be impracticable on account of mechanical considerations to make the wire, *w*, large enough to carry anything but a very small current.

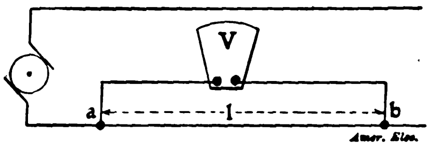

FIG. 5.—MEASURING DROP.

A voltmeter is always connected to the two points the difference of potential between which is to be measured. For example, if it is desirable to measure the e.m.f. between the two sides, *a* and *b*, of the circuit shown in Fig. 4, the voltmeter, *V*, would have one of its terminals connected to *a* and the other to *b*, as indicated. If the "drop" through a certain length of wire, *l*, of a circuit from *a* to *b*, Fig. 5, is to be determined, one terminal of the voltmeter is connected to *a* and the other to *b*. If it is desirable to find the drop through a lamp, one terminal of the voltmeter is connected on one side of the lamp and the second terminal on the other side of the lamp, as shown in Fig. 6.

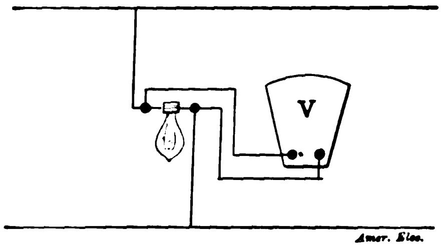

FIG. 6.—MEASURING DROP.

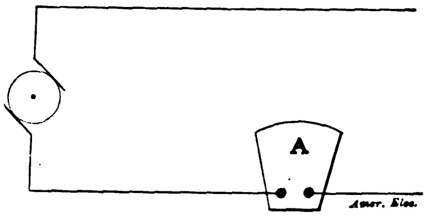

FIG. 7.—AMMETER CONNECTIONS.

An ammeter is always connected in series with the circuit the current in which is to be measured; *never* between the two sides of a constant-potential circuit like a voltmeter. If the wire of the ammeter coil is so large that it can carry the whole current, it is connected directly into the circuit, as shown at *A* in Fig. 7. If, however, the wire is small, it is connected in parallel with a shunt of low resistance, and only carries a small fraction of the total current. Such an arrangement is shown in Fig. 8, in which *A* is the ammeter and *S* the shunt. For circuits which carry large currents, this arrangement is always used, because otherwise the coil of the ammeter would have to be very heavy and consequently the instrument would be excessively bulky. Also, this arrangement of connections must always be used for a hot-wire ammeter, as explained in the paragraph relating to hot-wire instruments.

In cases where a continuous record is desirable and a great degree of accuracy is not necessary, a voltmeter arranged, as shown in Fig. 9, or an ammeter, as shown in Fig. 11, may be used. The operation of the voltmeter depends upon the principle that two solenoids will attract each other if placed near together so that the adjacent ends are of unlike polarity, and that of the ammeter, upon the principle that a solenoid will attract a piece of magnetic material, such as a disc of soft iron, placed near it.

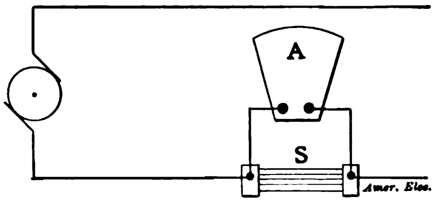

FIG. 8.—SHUNTED AMMETER.

The voltmeter, Fig. 9, has two current coils, *a* and *b*, one of which, *a*, is rigidly fastened to the frame of the instrument, while the other, *b*, is movable. It is carried by a pair of springs, *s*, s_1, which support a shaft, *c*, the shaft being fastened to the coil, *b*. An arm, *d*, is attached to the spring, s_1, and moves with it, and hence with the coil. At the upper end of the arm, a pen, *p*, is fastened, which rests upon a chart marked with radial lines, which indicate time, and circles, which indicate volts. This chart (shown in Fig. 10) is uniformly driven by a clock, *f*. When current passes through the coils, the fixed one, *a*, attracts the movable one, *b*, thus causing the pen, *p*, to move away from the centre of the chart, and the movement of the chart causes the pen to draw a continuous line, which indicates at any time the volts at the terminals of the instrument.

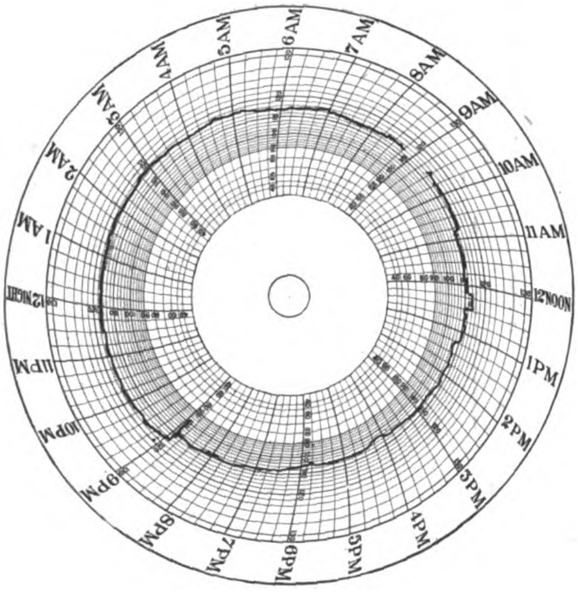

FIG. 10.—RECORDING VOLTMETER CHART.

The arrangement of the ammeter, Fig. 11, is similar to that of the voltmeter, except that in place of the moving coil, a thin disc armature, *b*, of iron is used, the rest of the mechanism being exactly the same. The method of operation of this instrument is precisely the same as that of the voltmeter. The chart, in this case, is graduated so as to read amperes. For currents up to about 1,200 amperes, ammeters of this description are made to carry the whole circuit current. For larger currents, a low-resistance shunt is used in parallel with the instrument, as shown in Fig. 8, and explained in a previous paragraph.

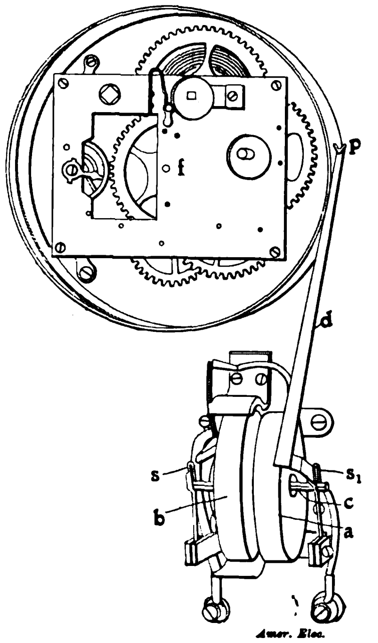

FIG. 9.—RECORDING VOLTMETER.

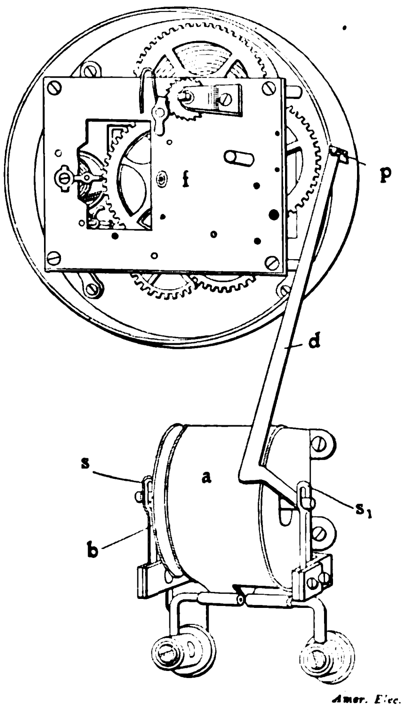

FIG. 11.—RECORDING AMMETER.

Letters on Practical Subjects

Automatic Cut-out for Alternating-Current Motors.

To the Editor, American Electrician:

The accompanying sketch shows an automatic cut-out devised by the writer for disconnecting an induction motor when the power is cut off from the line. The arrangement, of course, is applicable to any other kind of motor. It consists of a small casing attached to the end of the motor shaft and containing a number of steel balls which, when the shaft is at rest, settle down in the casing and connect the central pin with the outer shell. The pin and the shell are connected to two collector rings, to the brushes of which are carried the terminals of a local circuit that includes two cells of storage battery and a relay magnet, *M*. So long as the motor is in motion the balls are thrown by centrifugal force to the walls of the casing and spread out so that they do not come in contact with the central pin. When the motor comes to rest the balls settle down in the bottom of the casing and close the local circuit of the storage battery and relay magnet; the magnet attracts the latch, *L*, and releases the weight, *W*, which pulls open the main switch. This arrangement has worked very satisfactorily in connection with induction motors driving irrigating pumps and located in little scattered substations. The stations are visited every three hours by an attendant, but in the event that the current is taken off the line for any reason it would take too long a time for the attendant to make the rounds and switch

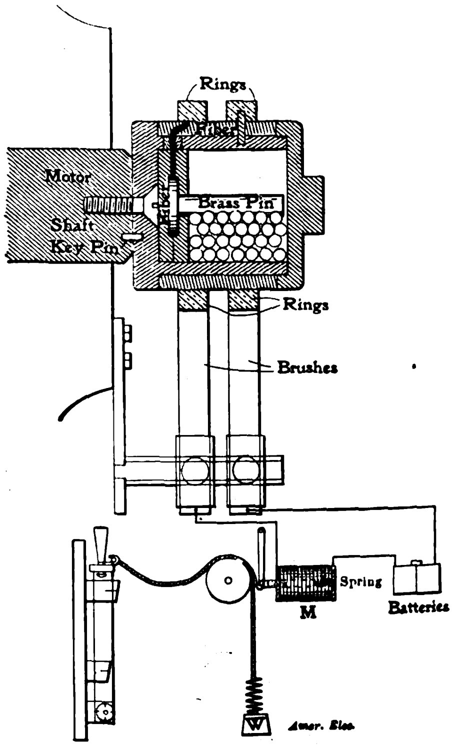

FIG. I.—AUTOMATIC CUT-OUT FOR ALTERNATING CURRENT MOTOR.

off all the motors. The arrangement shown obviates this necessity, so that when the plant shuts down unexpectedly it may be started up again just as soon as the cause of the shut-down is corrected without taking the precaution to go around and disconnect all of the motors. Of course, it is necessary for the attendant to make the rounds and start the motors up again after a shut-down, but this involves a less important delay than would be entailed by keeping the plant shut down long enough for the attendant to make the rounds in the first place and disconnect the motors. F. P. DE WILDE.

Lundy, Cal.

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Mr. Merrick's Revised Problem in Switches.

To the Editor, American Electrician:

The accompanying diagram, Fig. 2, is submitted as a solution to Mr. Merrick's revised problem and fulfils the additional conditions mentioned in his letter in the August number of the AMERICAN ELECTRICIAN. The switches are double-pole, with single and double-contact, and step-by-step mechanism; for the sake of clearness the blades are shown not touching any of the contacts, but of course in practice they would be always resting on one of the three points. The two blades of each switch are fastened rigidly together so that they move in unison. Assuming that all the lights are extinguished and that all of the switch blades are on the first point, except those on the fourth floor, which may be assumed to be on the second point, pushing the button on the first floor twice will light the lamps on the first and second floors. Then pressing the button on the second floor once will extinguish the lamps, and pressing it a second time will light the lamps on the second and third floors. This operation can be carried on clear up to the top floor if necessary, or any one of the switches may be left in the position which extinguishes all of the lights without preventing a person coming in later from going through the lighting cycle. The arrangement of the switch blades in the sketch is purely diagrammatical; when the blades are on the third point, it is intended that the next push of the button will shift them to the first point again, the rotary motion being continuously in one direction.

New York. C. H. POOL.

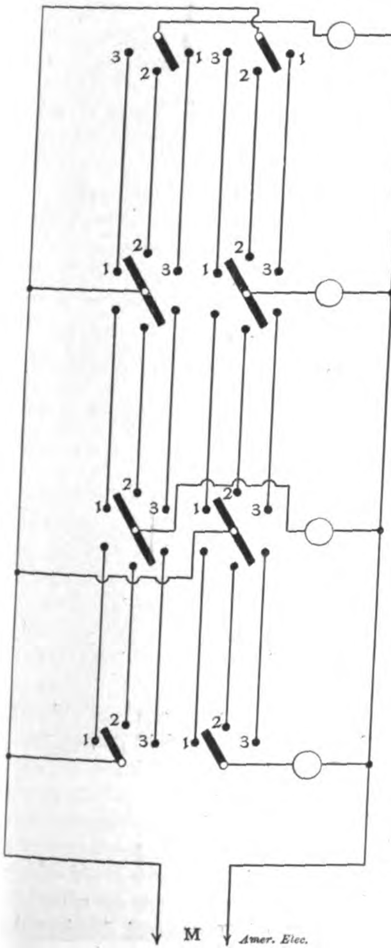

FIG. 2.—MR. POOL'S SOLUTION.

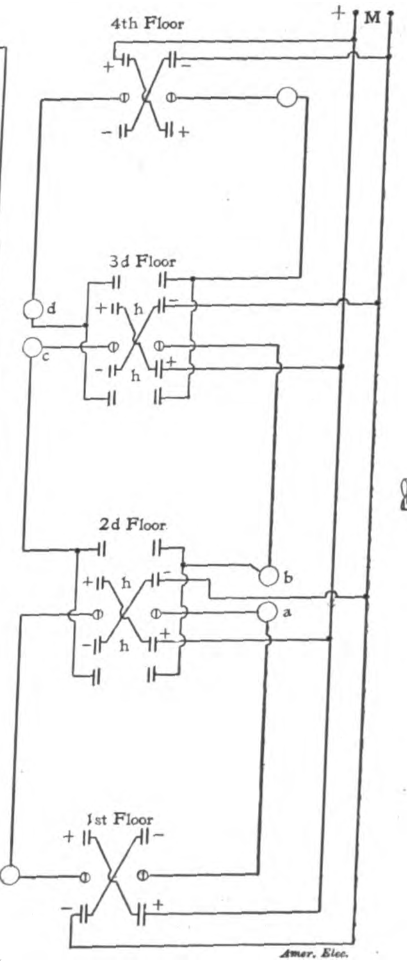

FIG. 3.—MR. MARSHALL'S SOLUTION.

To the Editor, American Electrician:

The enclosed diagram, Fig. 3, is submitted as a solution of Mr. Merrick's second problem in switch connections. As the diagram indicates, I use one lamp and a double-pole, double-throw, single-break switch on the first and fourth floors, with two lamps and a double-pole, double-throw, double-break switch on each of the other two floors. The jaws marked *h* on these latter two switches are made considerably longer than the extreme outer jaws so that the switch blades may be left in contact with the inner jaws without touching the outer ones. When all the switches are down, with the blades of the second and third floor switches entering only the inner contact jaws, the lights are all out; if the first floor switch is then thrown upward, the lamp on the first floor and the lamp, *a*, on the second floor will be lighted. Then if the second floor switch is thrown upward and the blades pressed all the way in, the lamp on the first floor and the lamp, *a*, on the second floor are extinguished, and the lamps *b* on the second floor and *c* on the third floor are lighted. If it were desired to stop at the second floor and leave all the lamps extinguished, the switch would be thrown upward and pressed into the inner pair of jaws only. The changing from one pair of lamps to the other may, of course, be carried clear up to the top of the building. This arrangement fulfils Mr. Merrick's problem, with the exception that push-button switches are not used; but not being able to reverse the cycle either from the fourth or one of the intermediate floors, I do not consider this a practical arrangement. Moreover, it requires so much manipulation that a person not thoroughly familiar with it would be likely to become confused. There is no doubt that a special switch could be made to connect and disconnect the lamps in the manner indicated by Mr. Merrick, but it would be so clumsy as to make it undesirable for residence service. The only practical way of doing this kind of switching is by means of the old three-way and four-way switch arrangement shown by Mr. Snyder's diagram in the July number.

San Francisco. JOHN J. MARSHALL.

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Cutting Left-Hand Threads With Right-Hand Tools.

To the Editor, American Electrician:

It may be advantageous to some readers of the AMERICAN ELECTRICIAN to know of an easy method of cutting left-hand male threads with right-hand threading tools. This may be done by setting a right-hand tap in the crotch of one-half of an ordinary screw-plate die, with the threads accurately meshed, of course, and then inserting between the clear side of the tap and the other half of the die the rod to be threaded; between the rod and the free half of the die a thin sheet of soft metal, such as copper, is inserted to prevent the teeth on that half of the die from spoiling the thread on the rod. The dies are then closed to the proper extent by means of the screw in the ordinary manner, and a left-hand thread cut on the rod. This arrangement is indicated by the accompanying sketch, in which *t* is the tap and *r* is the rod to be threaded. The sheet of soft metal between the rod and the right-hand half of the die is indicated by the heavy black line. Of course this wrinkle is not of any particular interest to those having a full set of both right-hand and left-hand taps and dies, but inasmuch as the number of left-hand threads that one ordinarily has to cut is comparatively small, few machinists have a full set of left-hand dies. The writer has cut left-hand threads by this method with entire satisfaction.

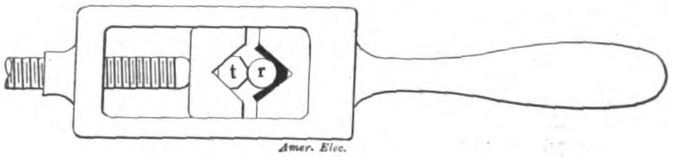

FIG. 4.—DEVICE FOR CUTTING LEFT-HAND THREADS.

New Haven, Conn. S. X. CALLAHAN.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

How can I oxidize brass or copper pipe on a small scale? W. B. P.

Immerse it in a solution of 2 ounces of nitrate of iron and 2 ounces of hyposulphite of soda to one pint of water, and leave it until the desired color is obtained. Then wash it thoroughly, dry and polish.

Cannot induction between two grounded telephone circuits be prevented by means of a ground wire run between the two telephone wires and grounded at both ends? W. J. N.

No; this would not have the slightest effect upon the mutual induction between the circuits.

Can electric light carbons be used in carbon zinc battery cells? (2) How can the copper coating be removed from the carbons? B. H. E.

Such carbons are a little too soft, but may be used with fair satisfaction. (2) Most of it can be peeled off, and the remainder removed by means of dilute nitric acid.

Can a 7½-h.p. 110-volt motor be used as a dynamo, and if so, what changes will be necessary? (2) How many incandescent lamps will such a machine supply? C. K. B.

Yes; without making any changes except to drive the armature at a somewhat higher speed than it runs when the machine is used as a motor. (2) Approximately 100 lamps.

Can an ordinary telephone generator be modified to give direct current without rewinding the armature? D. H. L.

It can be made to give a pulsating unidirectional current by putting on a two-part commutator, but in order to obtain a fairly smooth direct current an armature would have to be used having at least eight coils with an eight-segment commutator.

What is meant by resonance? (2) When two or more motors, each having a fractional power factor, are connected together on the same circuit, is the resulting power factor of the line lower or higher than it would be with only one motor connected? C. H. M.

A circuit is in a state of resonance when the total capacity and total inductance exactly neutralize each other. (2) The resulting power factor will be lower.

Why cannot compound-wound dynamos be operated satisfactorily in parallel with shunt-wound machines? J. L.

They can, provided the load is extremely steady so that the rheostat of the shunt-wound machine can be manipulated for each change of load. On a fluctuating load this is impracticable and parallel operation is, therefore, impossible for the reason that the terminal e.m.f. of the compound-wound machine will fall as the load increases.

What convenient solution can be used in a home-made polarity indicator? (2) Does it make any difference in which lead of a compound-wound dynamo the series winding is inserted? (3) Does it make any difference in which lead the ammeter is inserted? T. E. G.

Iodide of potassium dissolved in glycerine. (2) No. (3) Yes; the ammeter must be inserted in the lead opposite to the one in which the series winding is inserted; that is to say, the lead coming directly from one of the brushes of the machine.

What is the difference between a step-up transformer and a raising transformer, and how do these differ from the ordinary central station transformer? D. A. C.

There is no difference. A step-up or raising transformer changes the primary e.m.f. to a higher one at the secondary end. The same transformer may be used as a lowering or step-down transformer by supplying current at the proper e.m.f. to the high-tension side and distributing it from the low-tension side, just as in the case of the ordinary central station transformer.

How can the carbon of an ordinary battery be renewed after becoming polarized? (2) Can the porous cup of a Leclanché cell be refilled? (3) Why is lead used for the grids of a storage battery instead of lighter material? T. L. D.

Such carbons can usually be de-polarized by scalding them thoroughly in boiling water and drying them out in the hot sun. (2) Yes; melt the pitch off the top of the porous cup, pull out the carbon and empty out the old mixture. Put the carbon back and repack the cup with equal parts of pulverized carbon and black oxide of manganese and reseal the cup. (3) For the reason that no other metal except gold will withstand the action of the electrolyte in the peroxide of lead cell.

What is a good insulating material for wood bobbins for magnet coils? (2) Why is concentric wiring not used in the United States? (3) Why were old-fashioned smooth-core dynamo armatures wound with stranded conductors instead of solid flat conductors? J. S. M.

Ten parts of yellow resin and one part of white wax. The bobbins should be dried thoroughly at a temperature above the boiling point of the mixture and then plunged into the mixture when the temperature of the latter is about 350 degrees Fahr. Allow the bobbins to remain in the mixture until the latter cools to a slushy consistency. (2) Because it is not permitted by the Fire Underwriters, although it has been successfully used in Europe. (3) In order to reduce as far as possible the eddy currents induced in the conductor.

If a condenser and a reactance coil are connected in series across a constant potential alternating-current circuit and the voltage as measured at the terminals of the condenser is higher than the voltage of the line, does this represent the voltage that the insulation of the condenser has to withstand, or is it the impressed voltage of the line? (2) Why is the voltage at the terminals of a condenser under these conditions higher than the voltage of the line? J. W. E.

The strain to which the insulation is subjected is due to the voltage at the terminals of the condenser regardless of the voltage of the supply circuit. (2) It is not practicable to explain this in the limited space of this department; consult Sheldon's "Alternating-current Machines," or Jackson's "Alternating Currents," or Thompson's "Polyphase Currents," or Oudin's "Standard Polyphase Apparatus."

How can the core loss of a direct-current dynamo or motor be ascertained without the use of a dynamometer? (2) What should the core loss be in a modern machine of medium size? H. L. R.

Run the machine free as a motor at its rated speed and with the field separately excited to the normal extent and measure the armature current and the voltage at the brushes; multiply the current and voltage together in order to obtain the total watts taken by the armature. Then disconnect the field winding from the exciting circuit, block the armature so that it cannot revolve and pass a current through it of exactly the same strength as that taken while it was running; measure the e.m.f. at the brushes under this condition and multiply it by the current, which will give the power in watts that was wasted by the resistance of the armature circuit when the machine was running. The difference between this power and the total power taken by the armature while in motion will represent the core loss in watts due to hysteresis and eddy currents.

How may I burn a "lead" connection on battery plates? B. F.

This is successfully accomplished only after some considerable practice. When two pieces of lead have to be joined up by "burning," it is necessary to have both surfaces clean to start with, and employ a fairly large soldering iron, which will retain the heat well, and not cool down too rapidly. The exact temperature to which the soldering iron should be raised will be found after a little experimenting; if the temperature is too high, the surface of the lead to which the iron is applied will simply become oxidized, with the result that, instead of the metal flowing together when it melts, it refuses to unite at all, so that when the heat is taken away, and the metal allowed to cool, there is still no connection between the two surfaces; on the other hand, if the iron is not sufficiently hot, you will not obtain a good joint at all. A blowpipe flame, when manipulated with skill, is a ready method of making "burnt" joints, but requires even more practice before a job can be done quickly and well.

How is the size of wire in a dynamo field magnet coil determined in order to avoid over heating? (2) Why is it allowable to make the current density in armature conductors so much higher than the density in field coil conductors? (3) What is the best density for armature conductors? W. M. D.

In ordinary machines the size of wire must be such that the loss in power due to heating will not exceed ½ watt for each square inch of efficient radiating surface. See article on electromagnets and solenoids in the April and May, 1901, issues. (2) Because armature coils consist of only a few turns and move at a rapid velocity through the air, whereas field coils contain a large number of layers and are not subjected to the fanning action which serves to dissipate the heat in an armature coil. The heat produced in the inner layers of a field-magnet coil has no means of escape except by conduction through the outer layers. (3) There is no "best" density; the preferable density for any particular case depends upon the type of machine, the velocity of the armature periphery, and the allowable I^2R loss in the armature. Two thousand amperes per square inch is a fair density for most machines.

THE MECHANICAL EQUIPMENT OF THE ORANGE BREWERY, ORANGE, N. J.

In the brewing of beer the processes involved require but a small amount of power compared to the size of the apparatus employed, so that although a rather large building is necessary, a mechanical plant of quite moderate dimensions is capable of supplying the demands for power. Elevating and grinding grain, stirring mash, removing refuse, pumping beer and water, lighting the buildings and refrigerating the finished product while it stands in storage during fermentation, are the principal purposes for which power is needed, and of these all except the last consume relatively small amounts. The grounds cover a site approximately the size of an ordinary city block, and are located alongside the tracks of the Delaware, Lackawanna & Western Railroad.

In the boiler house there is a double equipment of boilers, one set being of the water-tube and the other of the fire-tube type, both of which were furnished by the E. Keeler Company, of Williamsport, Pa. The water-tube outfit consists of a three-drum battery of 400 horse-power, containing 212 4-inch tubes 16 feet long and a grate 11 by 6 feet in area. The other boilers, two in number, are of the return tubular form, 6 feet in diameter and 16 feet long, each containing 70 4-inch tubes and having a rated capacity of 200 horse-power. Sectional shaking grates, as made by the United States Grate Bar Company, of Elizabeth, N. J., are installed under all of the boilers. The smoke connections discharge into a 6-foot breeching which leads into a stack 125 feet high and 6 feet in diameter inside. Opposite the boilers against the outer wall is the storage space for coal, to which it can be conveniently delivered from cars standing on a spur siding close to the building.

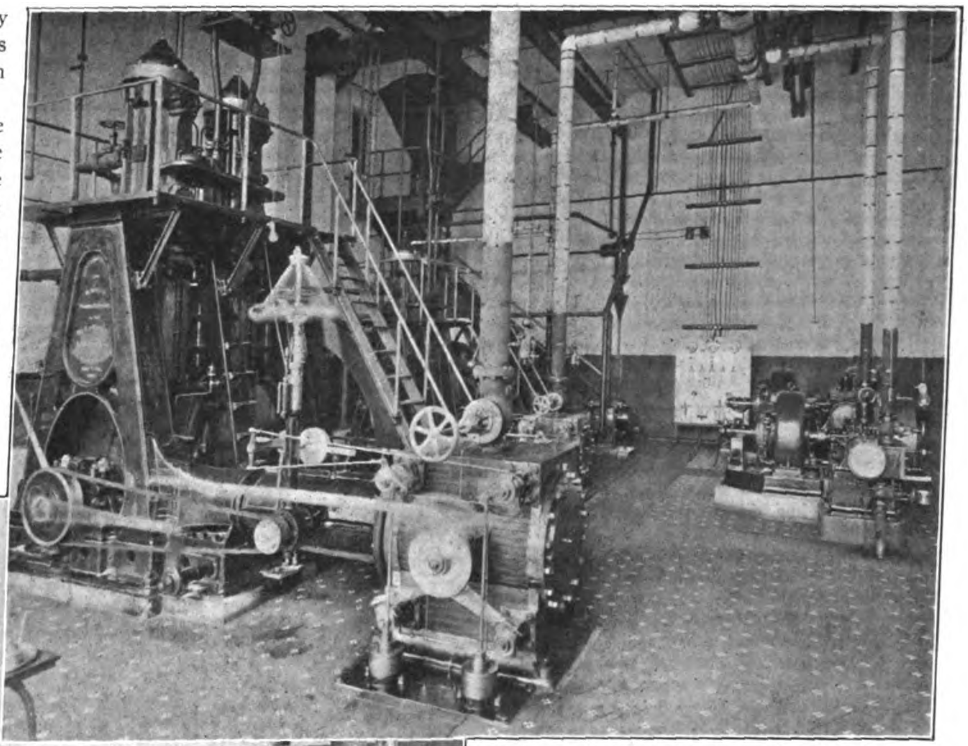

FIG. 2.—GENERAL VIEW OF ENGINE ROOM.

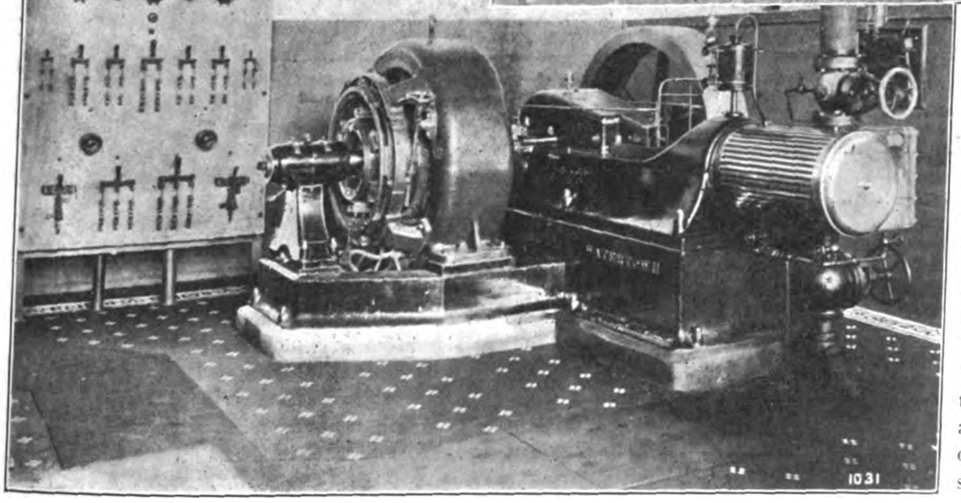

FIG. 1.—SWITCHBOARD AND DIRECT-CONNECTED GENERATOR.

Water for all purposes, including boiler-feed, comes originally from two artesian wells 700 feet deep under the building. From these it is first raised by air pressure to a reservoir beneath the wash house, consisting of an iron tank having a capacity of 250 barrels; from this tank it is pumped as needed to a 450-barrel storage tank on the roof. That portion which eventually becomes boiler-feed is heated by stages prior to its admission to the boilers, the first heating being accomplished by passing it over the coils of an ammonia condenser and oil cooler. The condenser is used in connection with the ammonia compression system of refrigeration and contains 3,590 linear feet of 2-inch pipe disposed in nine banks 21 feet long and 19 pipes high. The oil cooler forms the twentieth layer in the collection, and is two pipes higher, giving 440 linear feet for the cooling of the lubricating oil after it has passed through steam engine, air or ammonia compressor cylinders.

From a catch basin below the coils the cooling water drains to a heater outside of the building on the roof of an adjoining section, where by exhaust steam from the engines it receives a second heating. It next passes by gravity into a near-by open tank where the dirt and impurities collected on its surface are removed to the sewer. The rest of the water drains to a closed iron tank in the boiler room, from which the suction end of a 7.5 by 5 by 6-inch boiler feed pump takes it for delivery to the boilers through a second feed-heater located on the roof beside the first one and also using exhaust steam. As an alternative to this roundabout method of feeding the boilers, an injector may be used to supply them directly with cold water in case of emergency.

The lifting of the water from the wells to the reservoir is accomplished by a 14 by 16 by 23-inch air compressor, through a system known as the Bacon air lift. The compressor has a 5-foot flywheel running at 36 r.p.m., and produces a compression of 80 pounds per square inch. For the making of ice and the cooling of beer a De La Vergne Refrigerating equipment is used. There are two compressors, each having two ammonia cylinders, placed vertically above the shaft, in which the compressions occur on alternate strokes. A horizontal steam cylinder with Corliss-type valve gear operating as a simple slow-speed engine provides the drive. No brine is used in the circulating pipes, all coils being supplied directly with ammonia except those in the fermenting vats which contain water cooled almost to 32° Fahr. by previous contact with ammonia coils. This water is kept in circulation by means of a Tabor centrifugal pump direct-driven by a Crocker-Wheeler bipolar motor of 2 horse-power at 975 r.p.m. A 5¼ by 4¾ by 6-inch duplex steam pump is cross-connected with the rotary set so that they may be used interchangeably.

The electric generating plant for light and power consists of a 60-kw. Crocker-Wheeler direct-current generator direct-driven by a 12 by 14-inch Watertown engine, at about 275 r.p.m., and a similar but smaller set with a 30-kw. generator and an 8 by 12-inch engine running at 300 r.p.m. The generator e.m.f. is 220 volts; the current is utilized for lighting a total of about 250 incandescent lamps and supplying power to thirteen motors representing an aggregate of 123 horse-power.

The switchboard, shown in the view of the engine room, contains two ammeters, one for each generator, and a voltmeter with a double-point switch by which it may be connected to either generator. At the bottom of the board there are two 300-ampere, three-pole, single-throw switches for connecting the generators with the bus-bars and two single-pole circuit-breakers, one in the negative lead of each of the generator connections. The field regulating rheostats are directly above the main switches and circuit-breakers, while above the rheostats and below the meters are the distributing feeder switches. These from left to right are as follows: A 25-ampere switch controlling the current to the engine and boiler rooms, a 100-ampere switch for the machine house and filter room; a 100-ampere switch for the brew and stock rooms; a 300-ampere switch for all brew house motors; a 100-ampere switch for the bottling house and office; a 100-ampere switch for the wash and freezing rooms, and a 25-ampere switch for the stables and barns.

Of the principal constituents of beer (malt, hops and water), the malt presents the most difficult problem in the matter of handling. In this brewery the arrangements are such that from the time the malt is received until its refuse is discarded it is handled entirely by mechanical means. Freight cars bring the malt to the side of the building, where it is delivered through a chute into a hopper at the base of a motor-driven belt-and-bucket elevator, by which it is taken up and discharged into the top of two large cylindrical iron storage tanks. When about to be used, the malt is drawn from the bottom of the tanks and elevated to the top of the building by a second belt-and-bucket elevator traveling through a system of tubular sheet-iron ducts. To remove dirt and foreign particles it is first put through a cleaner, after which it passes successively by gravity through a grinding mill, to crack the shells of the grain; a scale-tank, where the charge is weighed; and a mash tub, into which the water is introduced while the mash is agitated by revolving paddles belted to a motor-driven line-shaft.

After the mashing process, the extract of the malt is drawn off through twelve brass faucets into the kettle, where the hops are added, and the wort is boiled. Finally a valve below the kettle is opened and the beer runs into a receptacle on the floor below. This contains a strainer through which the liquid is drawn by a Taber rotary pump at the rate of four barrels per minute, and pumped through an all-copper system of piping to the top of the building. It is then allowed to descend over a Baudelot cooler to vats in the fermenting room, where it is kept while that process is undergone, after which it goes into cold storage.

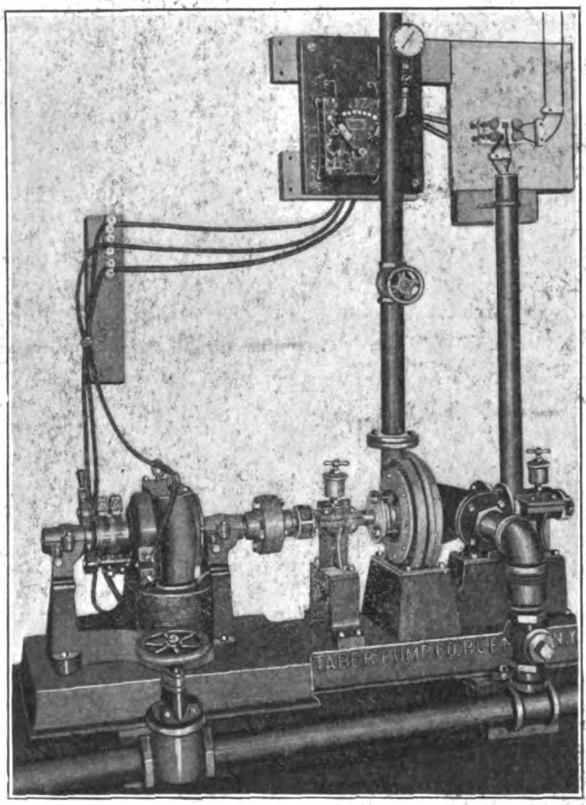

FIG. 3.—MOTOR-DRIVEN PUMP.

The malt remaining in the mash tub after the extract has been withdrawn is a salable by-product of value as a cattle-fattener; consequently for its disposal a scheme was sought which would remove it quickly and economically to an accessible location for intending purchasers. Since the mash while wet is very plastic it was found that such a scheme was possible through the use of a rotary pump similar to the one for the beer, but operated at a slower speed. This forces the mash through a long pipe from the end of which it may be discharged into the customers' wagons. Both rotary pumps are belted from a motor-driven line shaft.

Another ingenious mechanical process in use in the brewery is that employed for washing the kegs before refilling. After a thorough flushing the barrels are filled with water and placed on the machine for washing the outside. This is provided with four rubber-tired rollers rotating in the same direction, and upon these the barrel is placed and caused to revolve in the opposite direction, while adjustable brushes, with water playing through them, are brought to bear against the ends and side. When the barrel is thoroughly cleaned it is rolled down the runway to an inspector who examines the interior with the aid of a slim electric lamp dropped through the bunghole. If the loose dirt is not all removed it is washed over again, and if there are any bits of wood or paper too large to be rinsed out they are fished out with a sharp iron rod.

The brewery is operated by the Orange Brewery Company, of Orange, N. J., of which Mr. W. F. Wurster is the general superintendent and Mr. John Miller the operating engineer. The principal contractors for the various parts of the work were Charles Keester & Co., of Chicago, for the conveying apparatus; the De La Vergne Refrigerating Machine Company, of New York, for the entire refrigerating system, and the Crocker-Wheeler Company, of Ampere, N. J., for the generators and all electric motors except those included with machinery under special contracts.

◆◆◆

ELECTRICAL POWER INSTALLATION OF THE INDUSTRIAL WORKS OF BAY CITY, MICH.

The Industrial Works of Bay City, Mich., one of the largest manufacturers of railroad wrecking cranes in the world, has recently added to its electrical power equipment, four Westinghouse generators, and a number of induction motors. In addition to wrecking cranes, the Industrial Works also manufacture smaller cranes and transfer tables.

The new generators consist of one 150-kw. and two 30-kw. 110-volt direct-current generators, and one 200-kw. 220-volt three-phase alternator operating at 60 cycles. This combination of machines gives a very flexible power system. The alternator is used for power purposes entirely; giving the best results for motors located in inaccessible places. The large direct-current generator is also used exclusively for supplying power, and furnishes current for the operation of cranes and transfer tables and testing motors on cranes. The two 30-kw. generators are used for lighting. The switchboard arrangement is such that these two machines may be run either in series or multiple, the latter case being desirable when they are used for testing purposes on a 220-volt circuit.

The distribution of power and light is accomplished by means of distributing boards placed in the various shops, these being located at some distance from the power house. Communication between the power house and the shops is obtained through an underground tunnel, supports being provided in the tunnel for carrying the main feed line. By this arrangement, while all of the main circuits are controlled from the engine room switchboard, small individual light and motor circuits are under the control of the foreman in each of the various shops.

Fig. 1 shows the main switchboard, one of the engines, and other portions of the engine room equipment. The switchboard installation was also furnished by the Westinghouse Electric and Manufacturing Company.

Fig. 2 is a view from another point in the power house, showing the four generators, and the jack shaft with its connections between engines and generators. The jack shaft and the rope drive were furnished by the Dodge Manufacturing Company, of Mishawaka, Mich. The shaft may be driven independently at either end or simultaneously at both ends, it being possible to cut off either engine by means of friction clutches, as shown in Fig. 2. Each generator is also driven through a friction clutch. Furthermore, either half of the shaft may be run separately by unbolting the flanged coupling, shown in the center of the shaft, and removing a plate, which is normally held between the two halves. The system shown, while taking rather a large amount of room, is a very flexible one, both in operation and as far as the addition of new machines is concerned; and where space is not a very important item, the Industrial Works considers this arrangement quite as satisfactory as a direct-connected system.

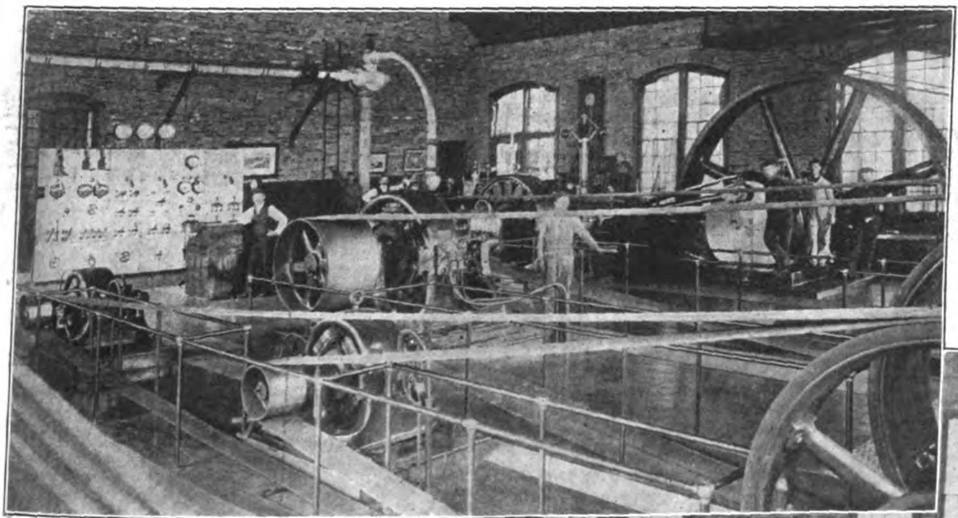

FIG. 1.—CORNER OF ENGINE ROOM.

Power is transmitted to the jack shaft by means of two engines, one a 400-h.p. tandem compound condensing Hamilton-Corliss, which ordinarily drives the shaft alone, and the other a simple Allis-Corliss of 200-h.p. capacity, which is held in reserve, or for operation when the full amount of power is not required.

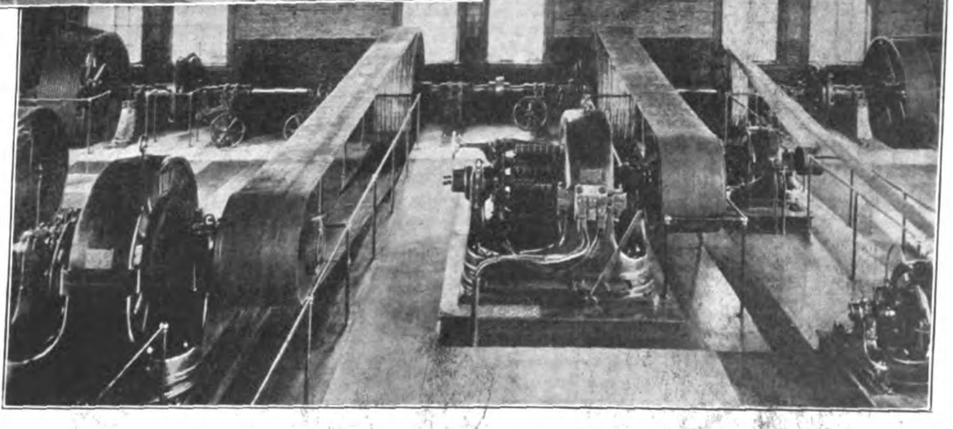

FIG. 2.—SHOWING GENERATORS DRIVEN FROM JACK SHAFT.

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Storage Battery Charging Temperature.—When charging, the temperature of a storage battery must not be allowed to exceed 100° F.; the temperature of a cell near the middle being taken as a guide.

AN IMPROVED BOILER CLEANER.

The importance of preventing or removing all scale incrustations from boilers for reasons of both economy and safety is so well established, and the difficulty of accomplishing it so well known, that every advancement in this department of engineering is of pecuniary interest to the man who pays the coal bills. Innumerable devices and means have been invented to prevent the formation of "scale" in the boiler, and, on the whole, the conditions have been slowly improved. Still, it may well be doubted whether any practical means can be devised that will positively insure the user against the presence of scale in the boilers. The result is that from time to time the scale that has formed must be removed either by entering the boiler and chipping it off by hand, or using some mechanical contrivance for doing the same work. To any one familiar with the construction of boilers, especially those of the return tubular type, where the scale forms on the outside of the tubes, the impossibility of cleaning the tubes of this scale by hand is at once apparent, and is the chief reason for the great favor into which mechanical cleaners have sprung. The inspection of this form of boiler is so difficult that scale is very often present without being known by the engineer. The construction of a return tubular boiler is such that almost all of the mechanical cleaners have taken the form of a machine which has entered the tube, and has a knocker or rapper that may be operated by hand or power, so as to rap on the inside of the tube sufficiently hard to jar the scale from the outside. A careful study of the problem has shown that the most effective and least dangerous method of rapping the tube consists in having the highest possible number of raps in a given time, which may be otherwise comparatively light blows, the effect of which will be to set up a more or less local, but very rapid vibration to the walls of the tube, which by reason of the more brittle and non-elastic character of the scale formation, breaks up, loosens and shakes off the latter, without subjecting the tube to any undue strain. The General Specialty Company, of Buffalo, N. Y., has devised the "torpedo" boiler cleaner shown by Fig. 1 herewith. The principle of this machine is that of a swiftly oscillating knocker driven by steam or air pressure. The device is said to be very simple in construction, consisting of a casing, piston, inlet and exhaust ports, and the knocker rod, which is firmly secured in the centre of the piston and is substantially a part of it. The cleaner is held centered in the tube by centering legs forced out to a limited movement by the steam or air pressure back of them. A test of the machine is said to have shown a speed of three thousand strokes and upward per minute, according to the pressure used.

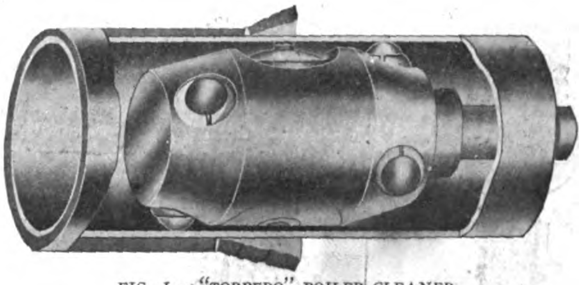


FIG. 1.—"TORPEDO" BOILER CLEANER.

New Apparatus and Appliances

TALMONT INCANDESCENT LAMP METER.

Fig. 1 shows an ingenious device brought out by the Talmont Electric Engineering Company of New York City. The device consists of an ammeter built in between a plug and a lamp socket. The ammeter is calibrated from 0 to 1.5 amperes, and may be used for either direct or alternating current, the upper scale being read for the former and the lower scale for the latter. On the instrument these are printed in black and red, respectively. The range of the meter is from 8 to 32 candle-power lamps on 64 to 220-volt circuits, and in the case of alternating current on frequencies of from 40 to 50 cycles. The instrument is fitted with Edison or Swan socket. In operation it is only necessary to screw the meter into the lamp socket, attach the lamp to the meter, turn on the current, when the lamp is lighted and the ammeter shows the current consumption. The instrument, which is said to be very accurate, can be carried in the pocket, the engraving shown being about one-half size.

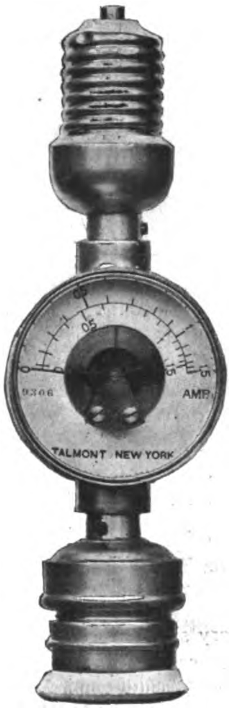


FIG. 1.

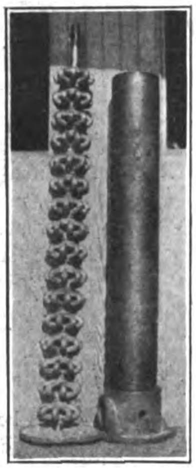


FIG. 3.

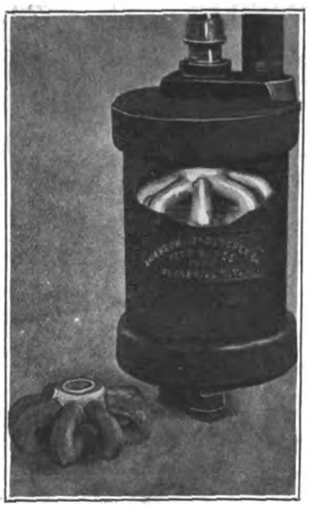


FIG. 2.—ANDERSON FEED-WATER HEATER.

ANDERSON FEED-WATER HEATER.

The feed-water heater shown by Fig. 2 herewith is based on a water heater section shown on the left of the engraving, this section being originally designed for a gas water heater. The sections are cast of iron and bronze, the iron section being galvanized on the inside and outside. The manufacturer of the heater, Anderson-McCutchen Company, of Peekskill, N. Y., claims that there is a full circulation of water through the section, and that the water is thoroughly agitated in passing from one section to the other, so that the "cold core" characteristic of coils and tubes is eliminated. The section being of cast metal must necessarily be heavy; but the manufacturer contends that the large heating surface in proportion to the water contained in the section, more than overcomes the objection to the thickness of the cast sections. The heater shown by Fig. 2 is of small size and the internal arrangement is clearly shown. Larger sizes may be had and the sections are being adapted for house heaters and several steam appliances. Precaution is taken so as to obtain secure joints and an expansion nipple, provided with a stuffing box, is applied where the water pipe issues from the heater. Fig. 3 shows a large feed-water heater dismantled.

NEW CABLE JOINTING DEVICE.

The accompanying illustrations show a new conical expansion cable joint and terminal connection which is being placed on the market by the Cable Joint and Electric Appliance Company, of New York City. Two forms of the joint are made—both on the same principle. In one form a threaded flange containing an internally tapered thimble is slipped over each end of the cable. A double conical plug of copper is inserted between the strands at the ends. When the joint is screwed up under pressure the ends of the cable are spread. As they are securely held by the taper in the thimbles, a positive joint is assured. In another form an internally tapered thimble is also slipped over each end of the cable; but instead of the double conical plug, a copper split ring connector is used. The ends of this split ring are tapered so that when the strands are brought together, the flared lips of the split ring are clamped tightly about the cable, forming an intimate and positive connection. Fig. 4 shows the double conical joint for stranded cables from 0 to 2,000,000 cir. mils. To each end of the cable a threaded thimble is applied, these thimbles having a flared inner surface as will be readily seen. One of these thimbles is mounted to permit the free turning of an exterior clamping sleeve having a screw-threaded connection with the other thimble—as illustrated. In this form of joint the connecting plug is a double cone of soft copper. When the two thimbles and sleeve are arranged as shown a hole is pressed into the end of each cable by separating the strands with a nail or punch to permit the insertion of the double-cone copper connector. The ends of the cable are then brought together, the entire sleeve is connected with the threaded thimble, and the parts screwed together under pressure. Fig. 5 shows how the double-cone connector forces the strands of the cable against the flared inner sides of the two thimbles. Fig. 6 shows the split ring joint for solid or stranded cables. It is essentially the same as the joint shown in Figs. 4 and 5, except that the connector is a split ring instead of a double cone. It is not wedged into the core of the cable, but, being tapered, is made to fit between the flared inner walls of the two thimbles and the ends of the cable.

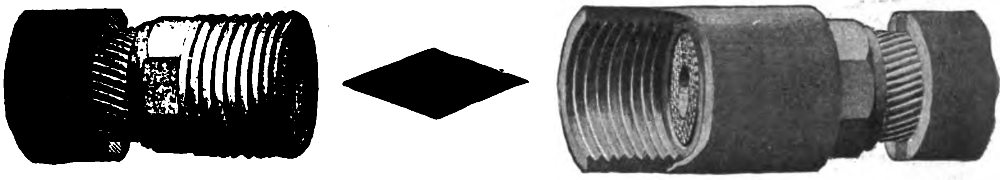


FIG. 4.—CONICAL EXPANSION PLUG CABLE JOINTING DEVICE.

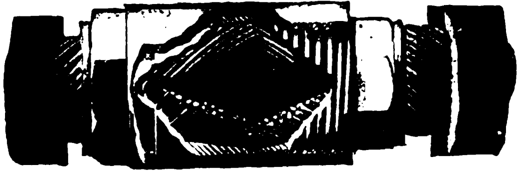


FIG. 5.—COMPLETED JOINT.

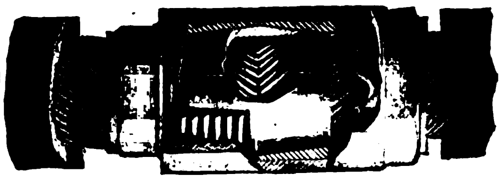


FIG. 7.—CABLE JOINT COMPLETE.

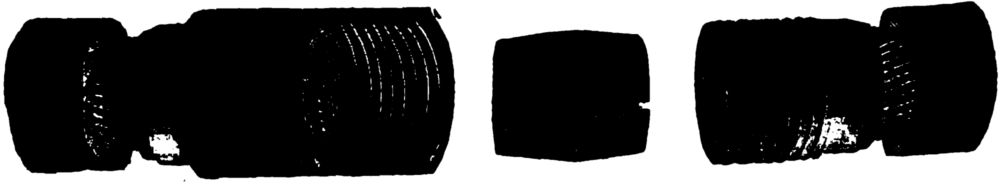


FIG. 6.—SPLIT RING CABLE JOINTING DEVICE.

The stranded cable terminal made by the company is shown by Fig. 8. In this form the eye has a threaded shank with a single cone projection or connector—a single cone being used simply because only one end of the cable is being dealt with. The single thimble is applied to the end of the cable, as described. The sleeve which fits over it is threaded to engage the threaded shank of the terminal eye. Simply tightening up of the sleeve forces the conical connector into the cable and spreads out the strands against the flared inner walls of the thimble. The principle is exactly the same as that illustrated in Figs. 4 and 5, except that a single instead of a double conical connector is used.

Numerous tests have been made of the conductivity of these joints, which have resulted very favorably for the construction. The copper terminals are of high conductivity, and the contacts are such as to secure a low resistance at the joint. This form of terminal does away with soldering joints, and also with more or less unsightly taping, which is necessary when making stranded cable connections. There is also less danger to the insulation of the cable.

NEW ENGLAND KEY SOCKET.

Fig. 9 herewith shows the 1903 type of key socket manufactured by the New England Electric Manufacturing Company, of West Somerville, Mass. The socket is made with Edison, T.-H. and Westinghouse base. A substantial two-piece porcelain, entirely enclosing the working parts and fully separating the opposite binding posts, is used in connection with two heavy brass pillars to support the switch key and circuit-breaking cam. The socket is said to be of great current carrying capacity, and has been made to undergo a test of over 20,000 revolutions under the requirements of the National Electrical Code. The circuit-breaking cam is operated by two phosphor bronze springs, giving quick action, the "break" between the cam and opposite connecting spring being over 3/16 in. All points of opposite polarity are separated by air spaces, or insulation, as required by the National Electrical Code, and the socket is made according to its specifications in all details.

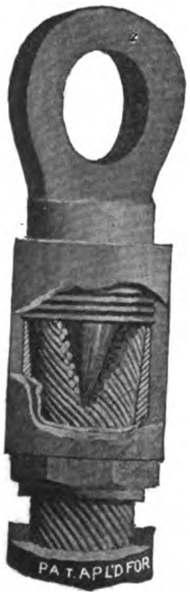


FIG. 8.—TERMINAL.

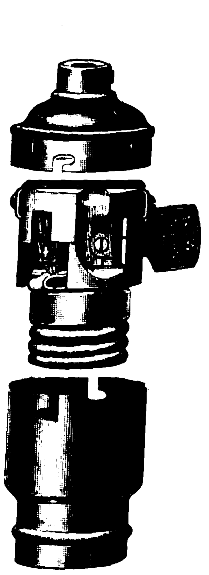


FIG. 9.

The shells and caps are lined throughout with a tight-fitting tube made by a special process and easily removable, but not loose enough to fall out in ordinary handling. The caps and shells are connected by an improved bayonet joint cap and shell connection.

S. K. C. INDUCTION MOTORS.

To meet the wide range of conditions which induction motors encounter in actual service, the Stanley Electric Manufacturing Company, of Pittsfield, Mass., manufacture three distinct types, which are separately treated below.

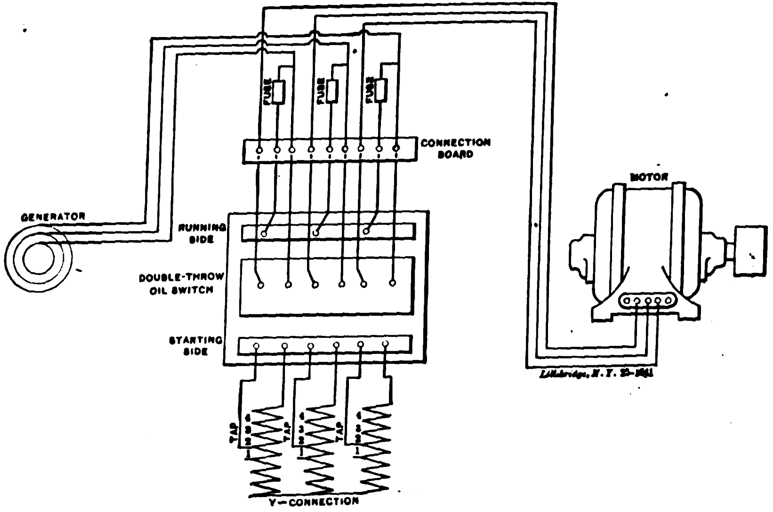


FIG. 11.—STARTING COMPENSATOR CONNECTED TO THE LINE AND MOTOR.

The motor shown in Fig. 10 is the simplest type. The armature or secondary is of the "squirrel-cage" type, and consists of straight copper bars laid in partly closed slots, with practically no insulation, and short-circuited by means of heavy end rings, as shown in Fig. 12. Injury to the armature either by heating or by mechanical displacement of the parts is said to be practically impossible, and the wear on the motor is reduced to that which takes place in the bearings. Owing to the extreme simplicity of armature construction, this type is the most desirable where the motor is not required to start heavy loads, or where a large starting current will not injuriously affect the potential regulation of the system. It is possible to start the motor by simply closing the line switch, and this method is used with motors below 5 horse-power. But as the first rush of current, when so starting, amounts to several times the running current, it is advisable to use with the larger sizes of motors a starting compensator to reduce the voltage impressed upon the motor, and thus decrease the current taken.

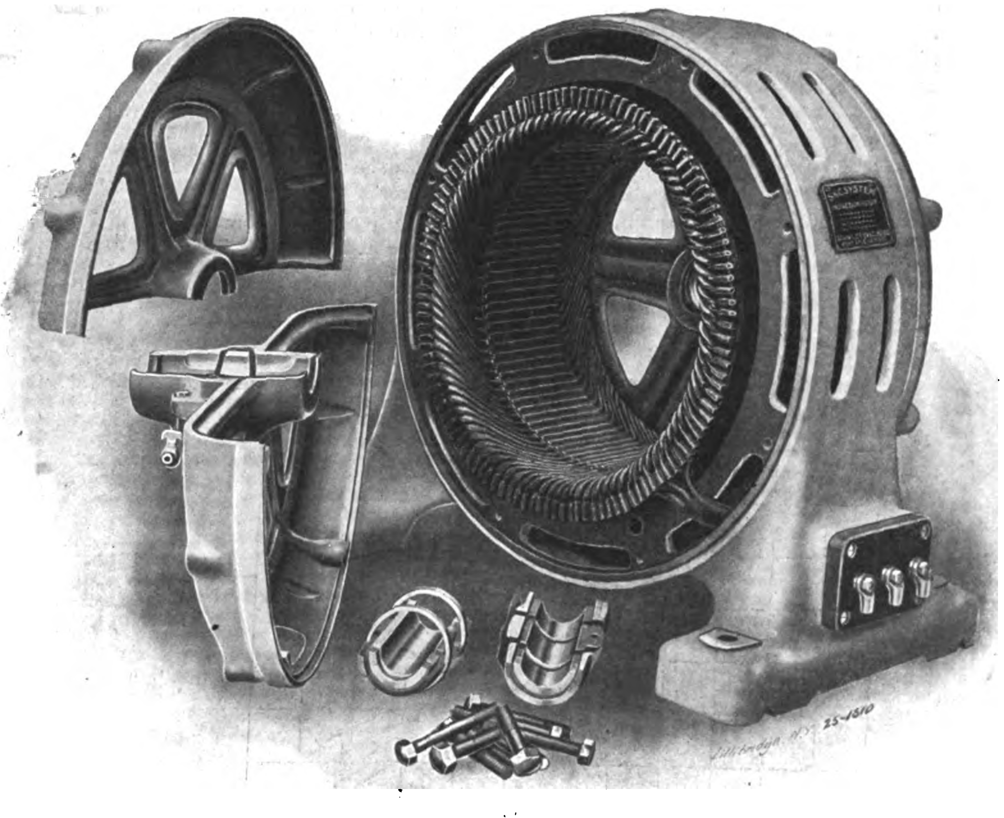


FIG. 10.—INDUCTION MOTOR WITH ARMATURE OR SECONDARY REMOVED.

The starting compensator consists of a

single coil transformer in each phase of the circuit, with taps brought out at various points of the winding in order that a number of potentials may be obtained. The compensator is provided with a double-throw oil switch, by means of which, after starting, the coils are cut out and the full voltage of the line applied to the motor.

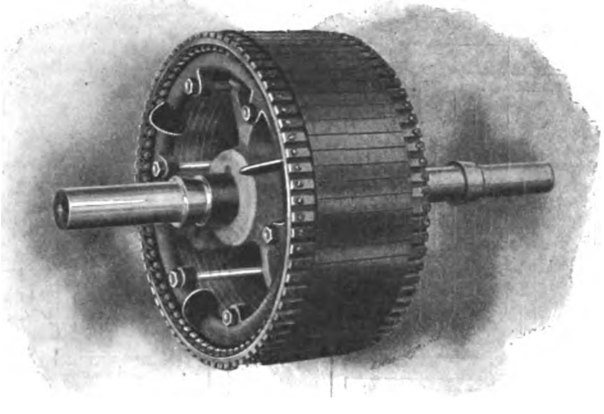
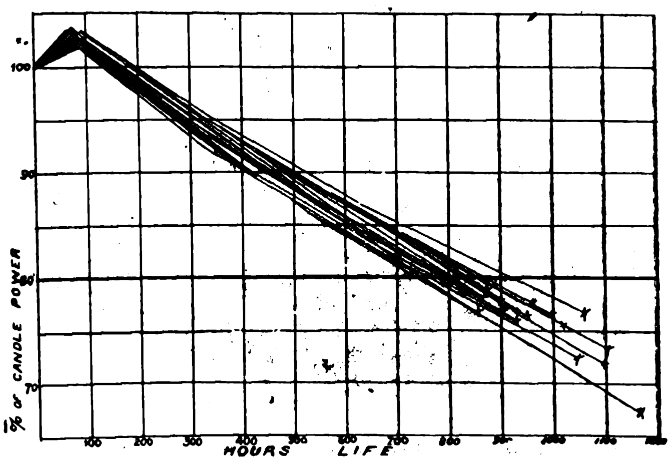


FIG. 12.—ARMATURE OF "TYPE A" MOTOR.

Fig. 11 shows diagrammatically the construction of the compensator and the method of connecting it to the line and to the motor.

The point at which the compensator should be connected will depend upon the torque which the motor must develop on starting. The compensators are normally connected to the first tap in the winding, so as to give the minimum voltage and therefore the lowest current. If, after this has been done and it is found that the torque thus developed is unequal to that necessary, a proper adjustment of the connections of the compensator to secure a higher potential can readily be made. In the second type of motor the starting current is kept low by introducing starting resistance within the secondary circuit. This type does not possess the same simplicity of construction as the type just described, owing to the fact that the armature has a polar winding and a device for varying the armature resistance is necessary, but it has this advantage—it will start a given load with a current materially less than that taken by the other motor. Therefore, it is recommended by the manufacturers where the motor must start heavily loaded and where a large current, such as the motor with short-circuited armature takes when starting at full load, would be objectionable.



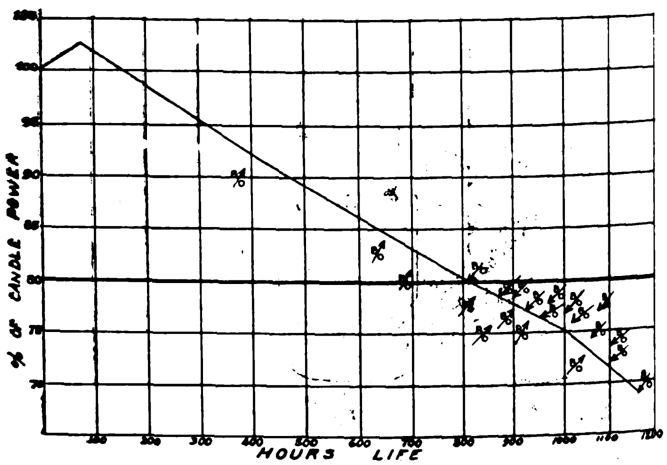


FIG. 14.—BRYAN-MARSH INCANDESCENT LAMP CURVES.—FIG. 15.

The starting resistance is placed within the armature spider, and leads are brought out from several points of the resistance to a set of contacts parallel to the shaft. A lever on the outside of the motor operates a sliding collar, which is arranged to pass over the contacts, so that the resistance, on starting the motor, can be short-circuited step by step.

In the third type of motor a variation in speed is secured by varying the resistance within the secondary or armature circuits. This resistance is located external to the armature so that the heat is generated at a distance from the motor and the resistance may be left continually in circuit if desired. The armature winding is similar to that of the motor just described. The leads from the winding are carried through a hollow shaft to the collector rings by means of which connection is made with a suitable controller for cutting in and out the external resistance. As is obvious, the controller constitutes a most satisfactory device for starting the motor.

The motors, it is claimed, can develop a torque of at least 200 per cent of their normal full load. Therefore, they are not liable to injury by temporary heavy overloads. The temperature rise of a motor of either of the three types on a continuous run at full load is said not to exceed 40° C. The speed of the two first mentioned types varies but slightly from no load to full load, the variation, it is claimed, not exceeding 2 per cent in the larger motors, and 5 or 6 per cent in the smaller sizes.

CABLE CAR FOR LINEMEN.

Fig. 13 shows a new design in cable cars which is fitted with a table on which an electrician may place his tools and material while making a splice. The car is made by the F. Bissell Company, of Toledo, Ohio, and consists of one piece of pipe, except where the short end of pipe is attached at the trolley. The trolleys are of light malleable iron and quite strong. The seat can be adjusted up or down or to the right and left to suit the size and convenience of the man using it.

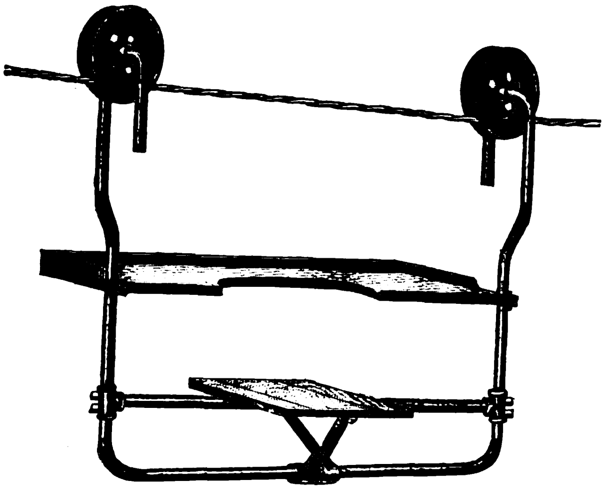


FIG. 13.—LINEMAN'S CAR.

A NEW INCANDESCENT LAMP.

The Bryan-Marsh Company has, after six months' work, perfected a new incandescent lamp which, while retaining the characteristics of the old lamp as to useful life, burns out before it becomes dim. Repeated tests of these lamps made during the summer, it is stated, show that they burn out almost immediately after the lamps have lost 20 per cent. of their initial candle-power. Most central stations regard the useful life of the lamp as ended when the lamp has dropped 20 per cent below its initial candle-power, and many of them send employes over their circuits to cull out the dim lamps. This expense, of course, will be obviated if the tests thus far made by the Bryan-Marsh Company prove to be conclusive, since lamps can be obtained that will automatically burn out before they get dim. The accompanying diagrams are submitted as representing graphically the results of the tests above mentioned.

NEW BOOK.

ELECTRICAL ENGINEERING MEASURING INSTRUMENTS. By G. D. Aspinall Parr. New York: D. Van Nostrand Company. Buckram; 328 pages, 6 ins. x 8¾ ins., 359 diagrams and illustrations. Price, $3.50.

This is a description of the standard voltmeters, ammeters and wattmeters used in England and on the Continent for direct and alternating-current circuits. The instruments are divided into classes according to their method of operation, the principle of each class being first carefully explained and then the way in which it is applied to the instruments. The illustrations are good and the descriptions clear. This is the only book of its kind thus far published, and although the author has restricted the descriptions almost entirely to European instruments, the principles of practically all of the instruments of three types that are in common use everywhere are well explained; and consequently, the work is of much value both as a text-book for students and as a reference book for engineers.

PERSONAL.

MR. G. C. FRENCH has been appointed superintendent of the Iowa Falls Electric Light & Power Company.

MR. E. H. BANGS has resigned the position of electrical engineer to the Southern Bell Telephone Company, at Atlanta, Ga., to accept a position with the Central Union Telephone Company.

MR. ROBÉRT A. BYRNS has been appointed eastern agent for the Northern Engineering Works, of Detroit, Mich., with headquarters at 120 Liberty Street, New York.

MR. GEORGE W. SCOTT, of Chicago, has been commissioned by the Executive Board of the Indiana State University, Bloomington, Ind., to design a complete heating, lighting and power plant for the University.

MR. JOHN B. ORR, recently a partner in the electrical engineering and contracting firm of James Mitchell & Co., Rio Janeiro, Brazil, has left that firm and established offices in Rio where he will act as manufacturers' agent for electrical machinery of all kinds of American makes.

MR. HENRY J. HALLBERG, for several years in charge of the arc lamp department of the General Incandescent Arc Light Company, recently resigned that position in order to accept the superintendency of the electric light department of the Cincinnati (Ohio) Gas & Electric Company.

MR. C. T. MALCOLMSON, recently of the staff of the department of machinery at the St. Louis Exposition headquarters, has been appointed chief engineer of the Lanyon Zinc Company, Iola, Kan., and has accordingly severed his connection with the Exposition staff.

MR. I. L. STOREY, the designer of the well-known Storey motor, has joined the staff of the Magneto Electric Company, Amsterdam, N. Y., and is very busy developing a new line of motors from one up to 10 horse-power, which that company will put on the market.

MR. HENRY C. MEYER, JR., the well-known consulting mechanical engineer, of New York, has been retained to design and superintend the construction of a central heating and lighting station to be erected at West Point, N. Y. The new station will constitute a part of the improvements to be made at the U. S. Military Academy.

MR. HENRY M. BLAKE, who has for some time been assistant to Mr. H. J. Hallberg in the arc lamp department of the General Incandescent Arc Light Company, New Lork, has succeeded Mr. Hallberg in charge of that department. Mr. Blake is a bright young engineer and his promotion is well earned.

MR. WILLIAM PASTELL has resigned his position as superintendent of motive power of the Worcester Consolidated Street Railway Company to accept a position on the railway engineering staff of J. G. White & Co., New York. Mr. Pastell is well known in New England electric railway circles and has had an extensive experience in this branch of engineering. He is said to be better posted on the subject of signals for electric railways than any other engineer in this country.

MR. C. L. HIBBARD, who for the past few years has been Chicago representative of the Varley Duplex Magnet Company, has resigned that position and will take charge of a new company which will manufacture and handle several electrical specialties. The name of the company will be announced later. The Chicago office of the Varley Company will temporarily be in charge of Mr. William Balke, who for the past five years has been Chief Inspector at the factory of the company.

MR. E. W. COLEMAN, manager of the Carrollton, Ga., Bell Telephone Exchange is evidently making friends by the carload to judge from the following extract from the *Carroll Free Press:* "On Tuesday morning Ed. W. Coleman, of the Bell Telephone Company here, came into our sanctum. Mr. Coleman is a printer by trade, and naturally became reminiscent during his visit. He told us there should be nothing in a paper that could not be read aloud in the circle where characters are made and where sweetness and delicacy and purity rule absolute. Up to this time we appreciated every word that he had spoken and thought that he was going to 'thaw' for a year in advance; but within the next fifteen minutes he had changed the subject entirely and had convinced us 'beyond a reasonable doubt' that in order to run a newspaper successfully it was necessary to place a telephone in our office. Mr. Coleman carries his head high on the telephone boulevard and never shies at independent companies or cuss words. He is a good newspaper man and a good telephone man. When he walks down the street everybody owing telephone rents grins and hurries on and Helfrich's sign of the big watch wig-wags in the joyousness of his presence. To have him near cures dyspepsia, removes warts, abrogates that tired feeling and charges the heyday in the blood with rejuvenation and renascence."

TRADE PUBLICATIONS.

FACTORY MOTORS. Rochester Electric Motor Company, Rochester, N. Y.—This is bulletin No. 65 and is a handsomely executed pamphlet devoted to Rochester motors for factory service.

PORTABLE TORQUE BALANCE. General Electric Company.—Bulletin No. 4331, in which is described a portable balance for testing the torque of recording watt-hour meters.

MOTOR-STARTING RHEOSTATS. General Electric Company.—Bulletin No. 4329, in which are illustrated and described the standard General Electric starting boxes or rheostats for stationary motors.

AIR BLAST TRANSFORMERS. Westinghouse Electric & Manufacturing Company.—Circular No. 1067, devoted to the Westinghouse air blast transformer, which is of the familiar shell type, but with a ventilated core.

THE ELECTROTHERM. H. W. Johns-Manville Company, New York.—An attractive folder illustrating the contrast between the old-fashioned hot-water bag and the modern electrotherm for the application of heat to the body.

LUNDELL MOTORS. The Sprague Electric Company, New York.—Bulletin No. 206, third edition, containing illustrations, brief descriptions and tabulated data relating to the well-known Lundell single-field-coil motor.

ELECTRIC GAS LIGHTING APPARATUS. The Holtzer-Cabot Electric Company, Boston, Mass. —Bulletin No. 147, containing illustrated descriptions of the improved Holtzer-Cabot automatic burner, candle automatic burners, spark coils, push-button keys, sectional cut-outs, batteries, etc.

A RUBEROID ALBUM. The Standard Paint Company, New York.—A nicely executed pamphlet containing a brief analysis of ruberoid roofing and a large number of letters from users of this well-known material, all of which are strongly commendatory.

ENGINE TYPE ALTERNATORS. Westinghouse Electric & Manufacturing Company.—Circular No. 1037, containing a well illustrated detailed description of the Westinghouse revolving-field machine, the field magnet spider being adapted for mounting directly on the engine shaft, in the manner usual with large alternators.

TELEPHONES. Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., and Chicago.—Bulletin No. 4 devoted to generator call telephones, and Bulletin No. 5 devoted to central energy telephones. Both books are beautifully executed and contain elaborately illustrated descriptions of the standard instruments and parts which go to make up the two classes mentioned.

THE STORY OF TWO LAMPS. The Shelby Electric Company, Shelby, Ohio.—This is a simple card containing a very clever comparison of the Shelby "Useful Light" lamp and the ordinary incandescent lamp with a double-loop filament. The reading matter relating to each lamp is written in the form of an autobiography, and presents the Shelby case very efficiently.

AUTOMATIC DIRECT-CURRENT CIRCUIT-BREAKERS. Western Electric Company.—This is publication No. 6005 and is executed in the elaborate style which characterizes all of the late Western Electric publications. It contains illustrations of single-pole and double-pole circuit-breakers for direct-current circuits, tabulated data relating to these, and a brief but complete presentation of the advantages claimed for this particular apparatus.

STANDARD MOTORS AND DYNAMOS. The Robbins & Myers Company, Springfield, Ohio.—This is publication No. 32 and is designated "The Standard Motor Book." It contains an illustrated description of the complete Robbins & Myers line of dynamos and stationary motors, which machines are built in sizes ranging from $^{1}/_{16}$ brake horse-power up to 15 horse-power, and from ½ kilowatt to 10 kilowatts in dynamo output. The book is extremely well executed and contains, in addition to the usual material found in such publications, a very useful page of diagrams showing methods of connecting up all standard types of motors and dynamos, and also two pages of instructive remarks concerning the selection, installation and care of motors.

BUSINESS NEWS.

THE C. & G. COOPER COMPANY, Mount Vernon, Ohio, has established a new Chicago office at 1436 Monadnock Block under the management of J. Holt Gates.

WATERTOWN ENGINE COMPANY, Watertown, N. Y., has established a Chicago office at 27 North Canal Street, which is managed by the W. P. Lyons Company.

THE VOUGHT-BERGER COMPANY, La Crosse, Wis., has perfected a new telephone outfit for party line work which will be put on the market shortly. This is said to be unlike any instrument heretofore built by any company.

INTERNATIONAL INSTRUMENT COMPANY is the name of an organization recently incorporated and located at Cambridge, Mass., for the purpose of manufacturing high-grade measuring instruments and testing apparatus.

CROUSE-HINDS ELECTRIC COMPANY informs us that the buildings, etc., of the County Fair to be held under the auspices of the Cortelyou Club, Brooklyn, will be decorated with incandescent lamps in Norbitt decorative sockets.

THE IRONTON ENGINE COMPANY, Ironton, Ohio, has appointed Fairbanks, Morse & Co., St. Louis, agents for Allfree engines in the St. Louis district and for the Mexican trade, and has appointed Harron, Rickard & McCone, San Francisco, agents for California, Nevada and Arizona.

THE LAMBERT-SCHMIDT TELEPHONE MANUFACTURING COMPANY, Weehawken, N. J., has discontinued its New York office and removed its Eastern headquarters to the factory at 85 Maple Street, Weehawken. The post office address is Station 1, Hoboken, N. J.

INTERNATIONAL CORRESPONDENCE SCHOOLS, Scranton, Pa., has established a course in advertising instruction. The chief of the new department is George W. Lord, who has had a wide experience in practical advertisement preparation.

THE BALL ENGINE COMPANY, Erie, Pa., continues busy notwithstanding the summer season. During July over thirty engines were sold for electric service, most of these being direct-connected engines ranging from 80 horse-power to 400 horse-power.

SCHUREMAN & HAYDEN, Chicago, have disposed of their business in elevator controllers and pump starters to J. L. Schureman & Co., who will continue at the old headquarters at 137 South Clinton Street. The dynamo and motor business of the old firm has been sold to the Gregory Electric Company, Chicago.

THOMAS E. CLARK WIRELESS TELEGRAPH-TELEPHONE COMPANY, Detroit, Mich., has established a school of wireless telegraphy for the benefit of those who desire to become familiar with Clark apparatus. This school is under the tutorship of R. W. Holmes, who is said to be an experienced wireless telegraph operator.

FRANCE PACKING COMPANY, Philadelphia, some time ago added to its line a department for the manufacture of all kinds of soft packing. The company has not heretofore said anything about the new line, preferring to wait until it had stood the test of actual service; it is now stated that the soft packings have proved eminently satisfactory under all conditions of service.

PENBERTHY INJECTOR COMPANY, Detroit, Mich., recently turned out Penberthy automatic injector No. 300,000. This means that 300,000 automatic Penberthies have been sold in a little over sixteen years, and considering the fact that it took almost ten years of hard work to convince engineers that an automatic injector was practical, this is indeed a phenomenal record.

ASTORIA STEEL COMPANY, Astoria, L. I., has about completed its large plant for the production of steel castings, and expects to be in position to fill orders about October 1. The plant is being equipped with the most modern machinery and apparatus and will have a capacity of approximately 100 tons a day. P. J. Ryan, formerly of the Penn Steel Casting Company, is sales manager.

SAWYER-MAN ELECTRIC COMPANY, in order to expedite the filling of orders, has established a distributing depot at the Central Stores of the Terminal Warehouse in West Twenty-eighth Street, New York City, a similar depot at Thirtieth and Market Streets, Philadelphia, and others in Boston, Chicago, Buffalo, Pittsburg, Denver, St. Louis, San Francisco, Atlanta, New Orleans and smaller cities.

JAMES McCRAE & CO., Chicago, report that the demand for "H. H." steam traps has crowded their manufacturing capacity to the utmost, and they have accordingly installed several new machines which will nearly double the factory's facilities. The firm also states that arrangements have been made with a large number of jobbers throughout the country to carry Roberts boring machines in stock.

THE GENERAL INCANDESCENT ARC LIGHT COMPANY, New York, has removed its general sales offices from 572 First Avenue to 529 West Thirty-fourth Street, the old building having been purchased by the Pennsylvania Railroad Company on account of the tunnel construction projected by that company. In making the removal the General Incandescent Arc Light Company has at the same time greatly enlarged its manufacturing plant and improved its facilities in all departments.

INTERNATIONAL POWER COMPANY, Providence, R. I., recently received from Mr. Edwin S. Cramp, vice-president of the William Cramp & Sons Ship & Engine Building Company, a highly commendatory letter concerning the Diesel engine built in this country by the International Power Company. Mr. Cramp stated that all of the claims made for this engine have been vindicated and that the engines in use at the Cramp works showed a saving of about 50 per cent. in the cost of power as compared with the prime movers previously employed.

LE VALLEY-VITAE CARBON BRUSH COMPANY, New York, recently had an unpleasant experience with a former employee. According to reports, this employee and a confederate established a rival concern, which the employee supplied with stolen goods from the Le Valley-Vitae Company's stock; these goods were then offered to regular patrons of the Le Valley-Vitae Company at reduced prices. This fraud, it is stated, was continued for about a year before it was finally run down and the guilty parties discovered.

CROCKER-WHEELER COMPANY, Ampere, N. J., recently completed an interesting power plant in the cement mill of the Great Northern Portland Cement Company, at Baldwin, Mich., in which there were installed 75 standard Crocker-Wheeler motors ranging from 7½ to 200 horse-power in size. The details of the plant were worked out by J. W. Prince, superintendent. Professor R. C. Carpenter, at Cornell University, was consulting engineer. Crocker-Wheeler apparatus is also being installed in the First National Bank building, Chicago, which will be the largest office building in that city. The generator plant consists of four 150-kw. Crocker-Wheeler dynamos direct-connected to Erie-Ball engines.

THE LAMP TESTING BUREAU, New York, reports that the growing demand for tests of incandescent lamps and other electrical apparatus has taxed its facilities to such an extent that the laboratory equipment will be immediately doubled. A suitable building of heavy fire-proof construction has been secured at the foot of Eightieth Street on the East River and the Bureau will remove its present laboratory equipment there and install the additional equipment just as rapidly as possible. When completed this laboratory will be probably the most complete one thus far established for doing commercial work. The scope of the Bureau was long ago extended beyond lamp testing; the laboratory contains facilities for testing and calibrating instruments of every description and making efficiency tests of dynamos, motors, transformers, etc.

DREXEL INSTITUTE, Philadelphia, has established a special engineering course in its School of Electrical and Mechanical Engineering, which has been added in order to meet the requirements of young men who, after completing a high-school or equivalent education, have gone directly into commercial engineering work and are handicapped by the lack of technical training. The new course is of only two years' duration, but is expected to be as thorough and efficacious as the usual course occupying four years, for the reason that the practical experience of the student in mechanical drafting and shop methods is expected to take the place of similar work in a four-year course, and because the student's greater maturity should enable him to advance more rapidly and with more certainty than an inexperienced student might. Full details may be had upon application to Arthur J. Rowland, professor of electrical engineering, or to A. Theodore Brugel, professor of mechanical engineering, at the Institute.

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IF YOU COAT THE PULLEY WITH
WARREN'S PULLEY COVER PUT ON WITH A BRUSH.
125 SQ. FT. $12.00; 40 SQ. FT. $5.00. — TO-DAY IS A GOOD DAY TO ORDER
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The Chicago, Milwaukee & St. Paul Railway is now running solid trains of palace sleeping cars, dining cars (serving meals a la carte) and first-class day coaches, through from Chicago to Calumet, Houghton, Hancock and other points in the Copper Country without change of cars, with direct connection for Marquette, Negaunee, Ishpeming, etc., and passengers from the East, South and Southwest will find this a most desirable route.
All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.

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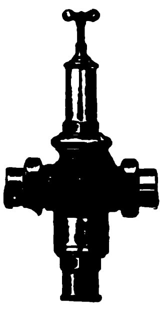

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They are adapted for every need and guaranteed to work perfectly in every instance.
Write for full information and splendid references.
THE MASON REGULATOR CO., Boston, Mass., U. S. A.

American Electrician.

Vol. XV. New York, October, 1903. No. 10.

ELECTRICAL EQUIPMENT OF A GRAIN ELEVATOR.

POWER PLANT OF THE SOUTHERN PACIFIC TERMINAL COMPANY AT GALVESTON, TEXAS.

BY C. W. WHITNEY.

The Southern Pacific Terminal Company has recently completed a modern steel grain elevator at Galveston, Texas. The elevator has a storage capacity of 1,000,000 bushels, and a carrying or transferring capacity from car to ship of 30,000 bushels per hour. The plant lies on the shore of Galveston Bay, and the ships are loaded by means of a main gallery, which is 1500 feet long, and extends from the elevator along the wharf. This gallery will permit the loading of two ships at the same time. It contains two large belt conveyors, each of which carries grain to a ship, or, if only one boat is loading, it can be located so that it can be fed by both belts.

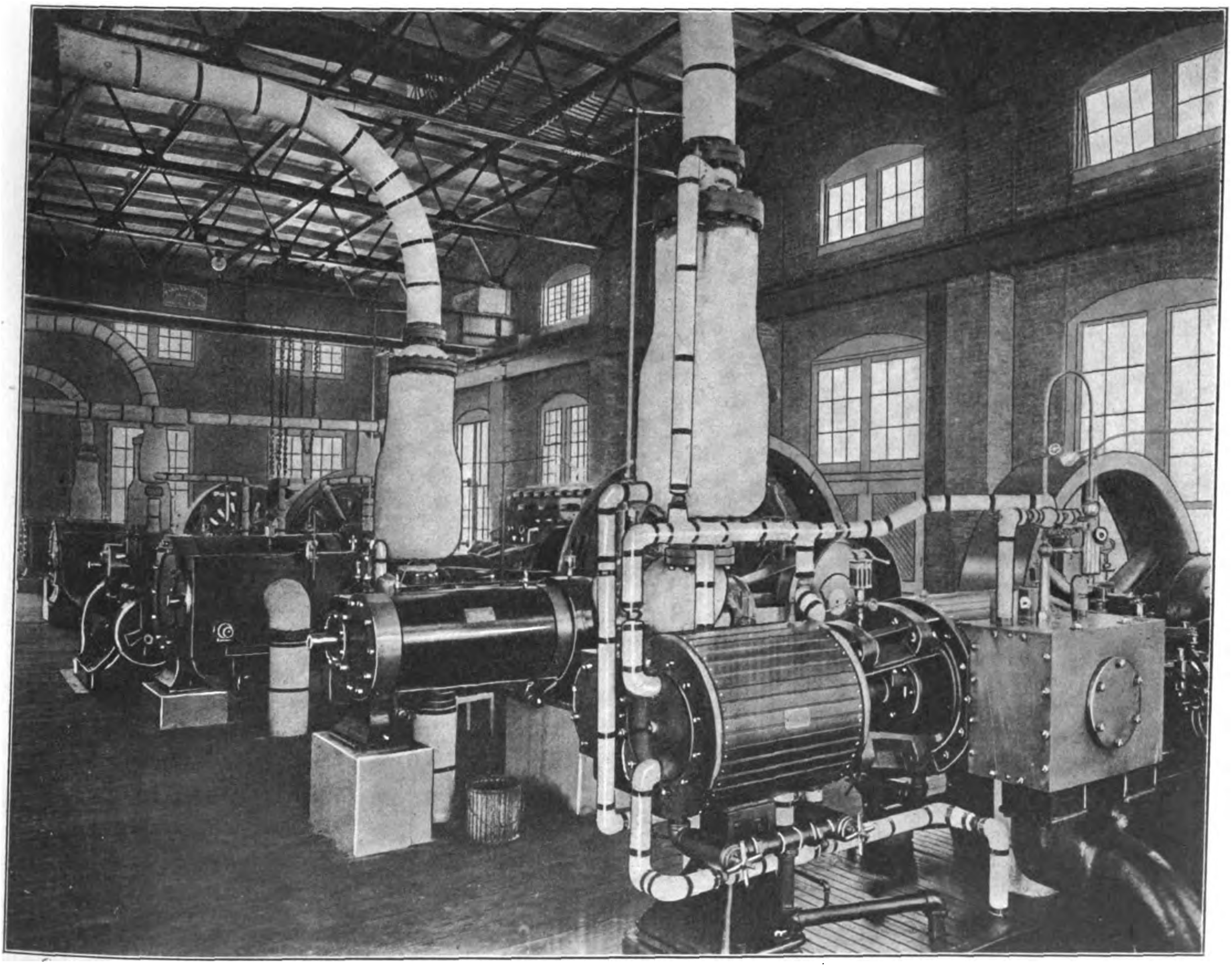


FIG. I. GENERAL VIEW OF THE SOUTHERN PACIFIC TERMINAL COMPANY'S POWER HOUSE.

The power house is a separate building, and is located 550 feet distant from the elevator. The entire elevator installation is driven by electric motors, and in order to provide the minimum risk from fire and explosion these motors are all of the induction alternating-current type. The feeder lines are carried on poles from the power house to the elevator, and consist of three 500,000 circ. mil three-phase circuit wires and a similar one of No. 0000 wire. The wires enter the belt gallery at the junction of the long and short galleries, and are carried in the short gallery to the elevator. There the circuits are distributed to the different motors in heavy iron-armored conduit. The conduits in this installation are extra heavy, in some cases three 750,000-circ. mil cables being carried in a three-inch pipe. The cut-out boxes were also specially designed for this plant. Two of these boxes may be seen in Fig. 8. Each box is 36 ins. by 26 ins. in size, and is provided with a 500-ampere quick-break three-pole switch and Noark fuses. The boxes are made of steel, and when closed are hermetically sealed so that no danger can arise from the blowing of a fuse.

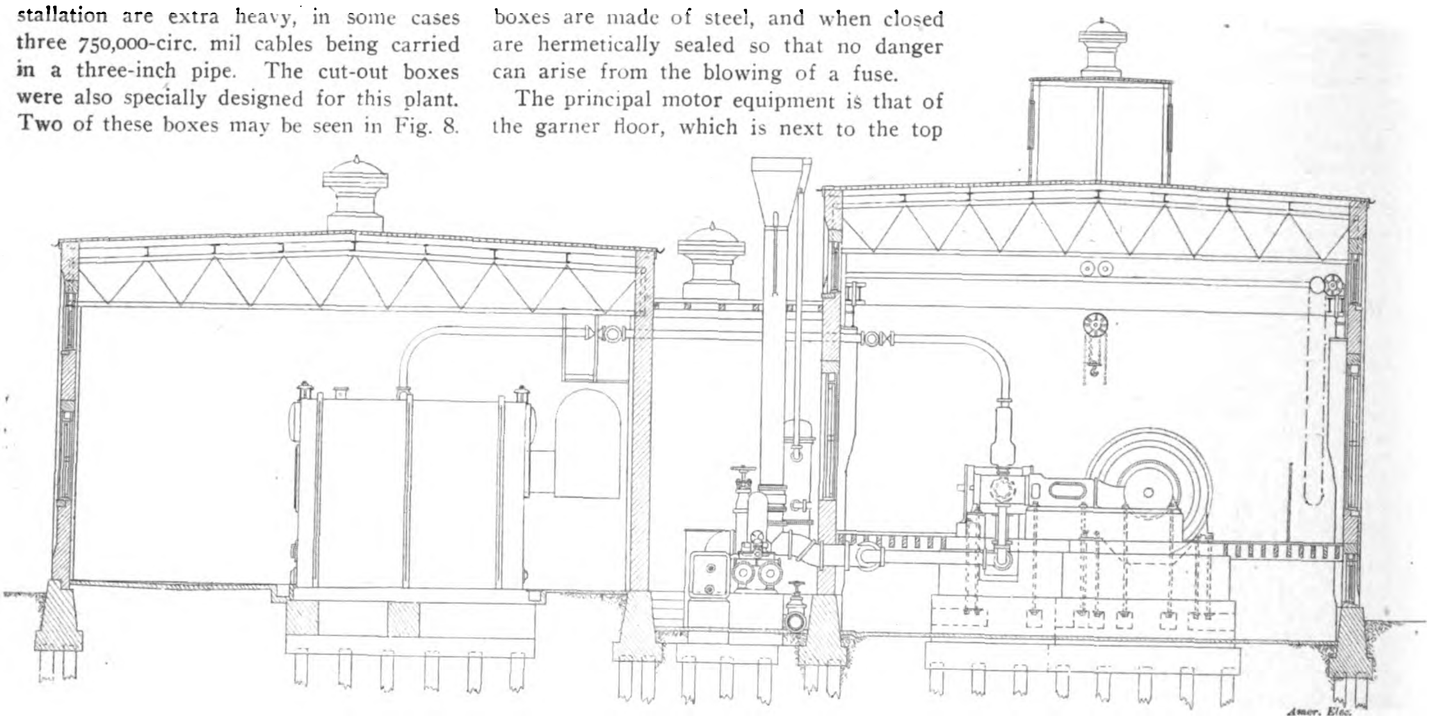


FIG. 2. CROSS-SECTIONAL ELEVATION OF POWER HOUSE.

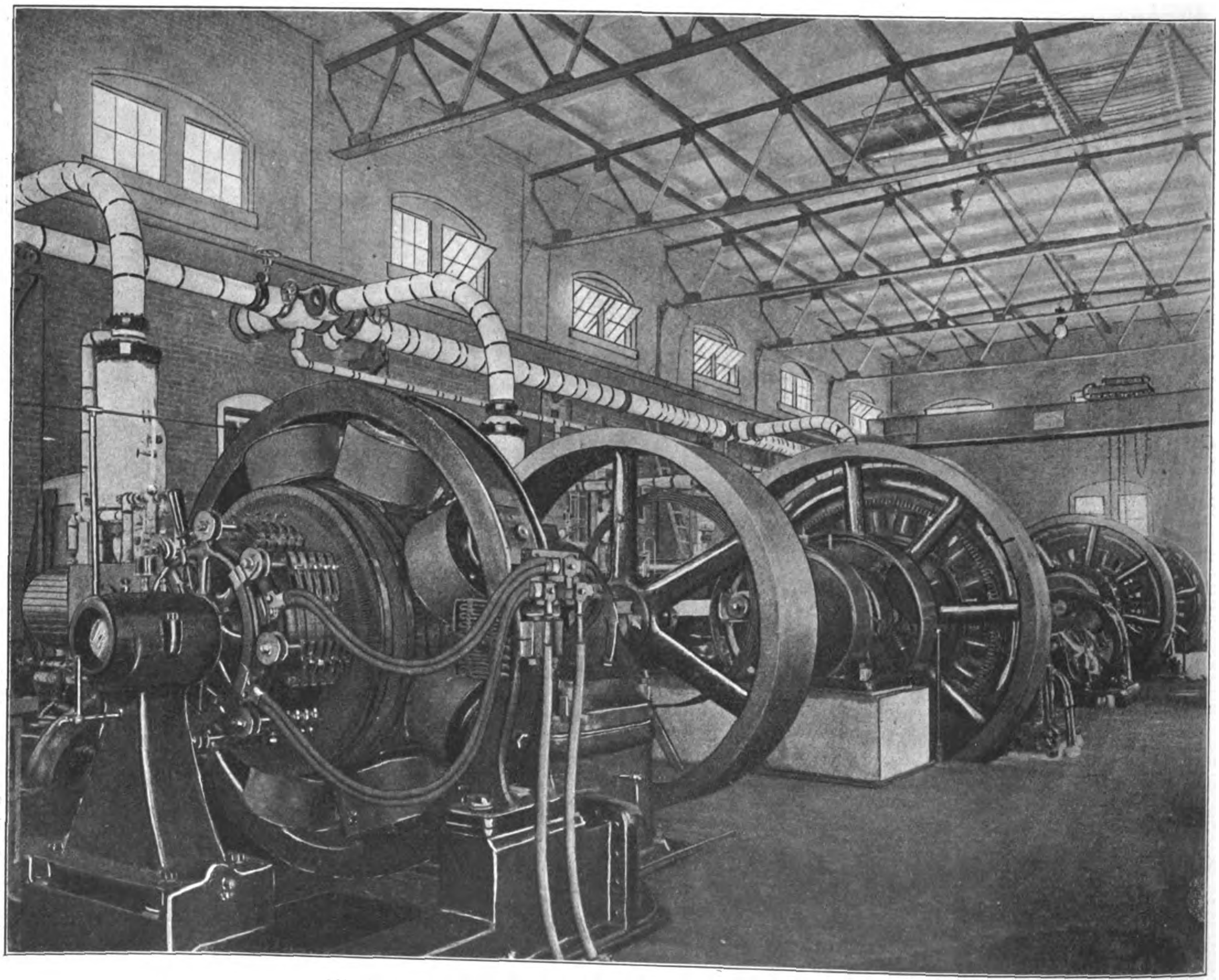


FIG. 3. GENERAL VIEW OF ENGINE ROOM FROM GENERATOR SIDE.

The principal motor equipment is that of the garner floor, which is next to the top floor of the elevator. Here are installed ten 75-h.p. motors, each driving an elevator leg, and a 40-h.p. motor which drives a conveyor belt. The 75-h.p. motors have a speed of 485 r.p.m., and the 40-h.p. motor has a speed of 728 r.p.m. All are connected to the machinery by rope drives, and a wire leads from each motor switch to the first floor of the elevator, so that in case of necessity the motor or any elevator leg may be instantly stopped from below by pulling on a wire.

On the first floor of the elevator are located two 100-h.p. motors, which have a speed of 485 r.p.m., and are used to drive miscellaneous general machinery on that floor, the connection with the main shaft being by rope drives. Fig. 11 is an excellent view of these motors. The starting compensator boxes and fuse casings are shown mounted on posts and connected to the motors by iron-pipe conduit. On this same floor there is also a 75-h.p. motor, which drives an oat clipper and a cleaning machine.

The rest of the induction motors used in the grain elevator operations serve to drive the belt conveyors that transfer the grain to the ships. For the short steel gallery that connects the elevator with the main gallery there are a 75-h.p. and a 40-h.p. motor, both located in a tower at the end of the main building. At the middle point of the main wooden gallery, in a motor tower, are placed three 75-h.p. motors, as shown in Fig. 14. Each of these motors drives a belt 750 feet in length. All five conveyor motors are so arranged that they can be instantly stopped at any point in the gallery by pulling wires which open emergency switches placed in the motor circuits at the corner of the gallery.

In the office of the elevator is installed an express telephone switchboard with self-restoring drops. There are eleven long-distance telephones in use at present, and some of the instruments are of the portable type. For instance, along the main gallery there are 22 different stations, and the workmen in this gallery are provided with two portable telephones, so that they can plug in at any station and give or receive instructions. Similarly, on the side gallery, there is one portable instrument with five stations. Other telephones are placed in the power house, first floor, garner floor, etc. The telephone equipment was

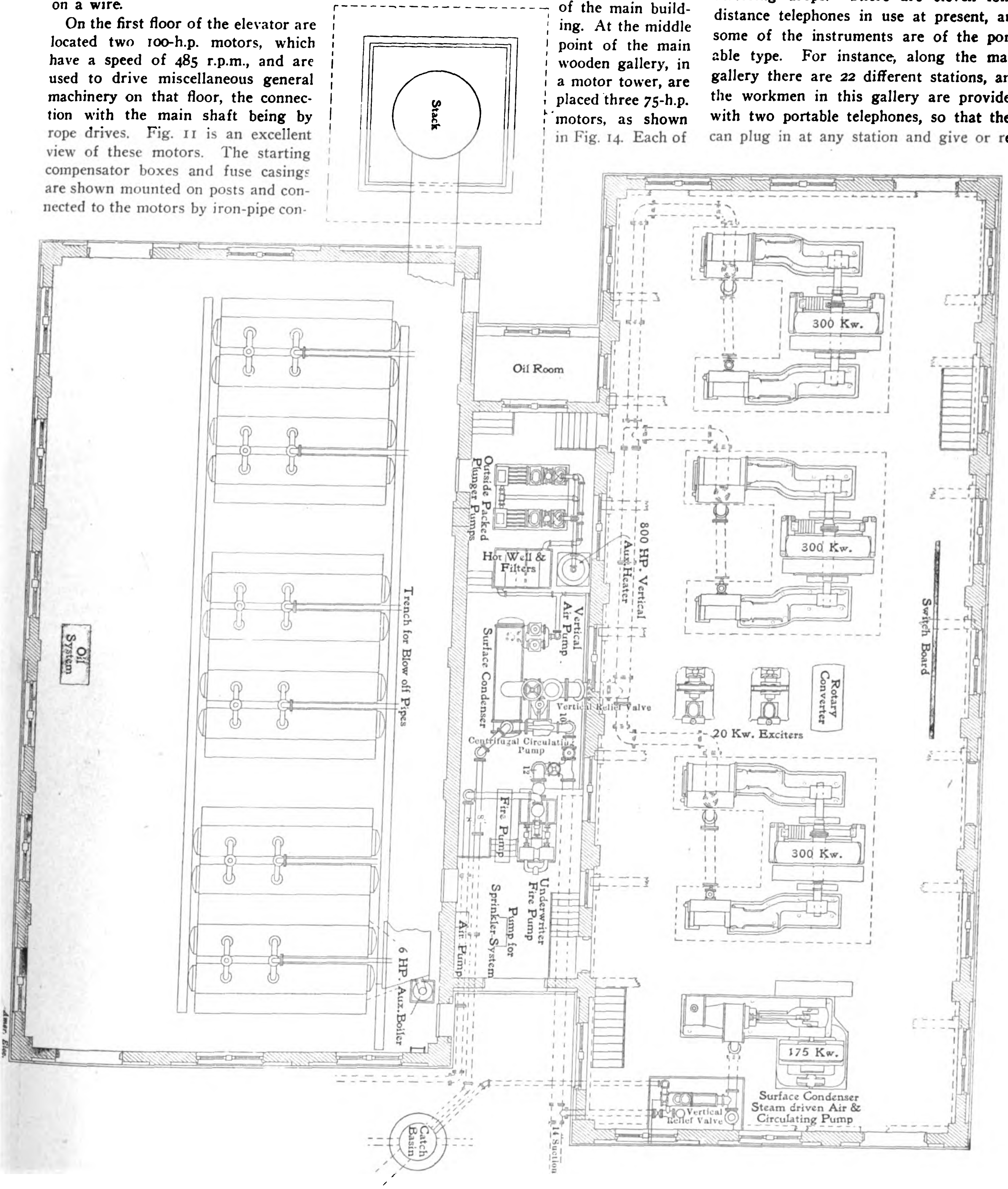

Stack
Oil Room
300 Kw.
300 Kw.
300 Kw.
175 Kw.
Outside Packed Plunger Pumps
Hot Well & Filters
800 HP. Vertical Aux Heater
Trench for Blow off Pipes
Oil System
Vertical Air Pump
Surface Condenser
Vertical Relief Valve
10
Centrifugal Circulating Pump
12
Fire Pump
Underwriter Fire Pump
Pump for Sprinkler System
Air Pump
6 HP. Aux. Boiler
Switch Board
Rotary Converter
20 Kw. Exciters
Surface Condenser Steam driven Air & Circulating Pump
Vertical Relief Valve
Catch Basin
14 Suction
Amer. Elec.

FIG. 4. PLAN VIEW OF POWER HOUSE AND PIPING.

installed by the Williams-Abbott Electric Company, of Cleveland, Ohio.

A very complete system of signal bells is also provided along the belt galleries and throughout the elevator with push-buttons at the desired points. By means of a code of signals the employees are enabled to handle the movement of the grain and regulate the speed of the conveyors through these bell signals very quickly and satisfactorily, the telephones being relied upon for unusual and more detailed instruction.

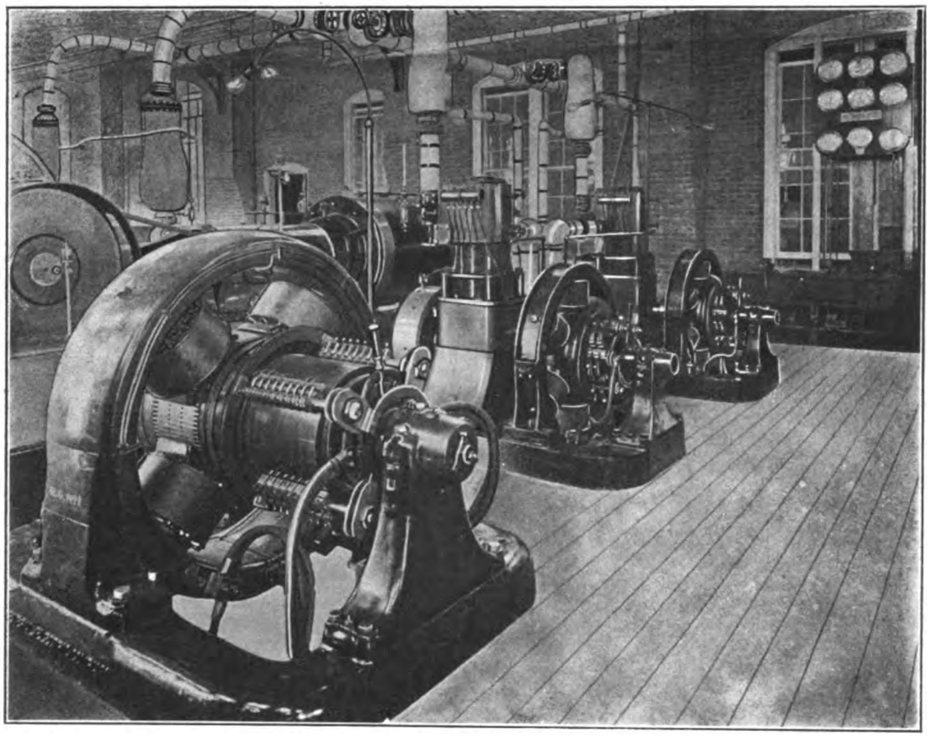


FIG. 5. ROTARY CONVERTER AND EXCITER UNITS.

An interesting freight handling equipment is installed on the wharf for use in handling freight of a general character to and from the ships. There are three ship's berths, and each berth is provided with seven electrically driven conveyors, making twenty-one in all. The conveyors are of the endless-belt type, about 36 inches wide and 50 feet long, and were built by the Link-Belt Machinery Company, of Chicago. Each conveyor is direct connected through gearing to a 10-h.p. shunt-wound direct-current motor, wound for 230 volts and operating normally at 650 r.p.m. The conveyors have a speed of about 200 feet per minute. At the outer or ship end of each conveyor is a hoisting gear to raise or lower the conveyor as the ship rises or falls during unloading and loading. There are also installed on the wharf two electric hoists for lifting heavy machinery and heavy pieces of freight from the ships and landing it on cars on the dock. Direct current for operating these conveyor and hoist motors on the wharf is supplied from the power house over a 500,000-circ. mil two-wire circuit.

The power house of the Southern Pacific Terminal Company is a separate one-story brick building with tar, felt and gravel roof. The boiler-room is 86 ft. 10 ins. long and 46 ft. 10 ins. wide; the engine-room is 102 ft. 10 ins. in length and 42 ft. 10 ins. in width. Between the two rooms is a space for pumps, condensers, oil room, etc., that is 13 ft. 4 ins. wide and about 71 feet long. Plan and elevation drawings of the power house are shown in Figs. 4 and 2.

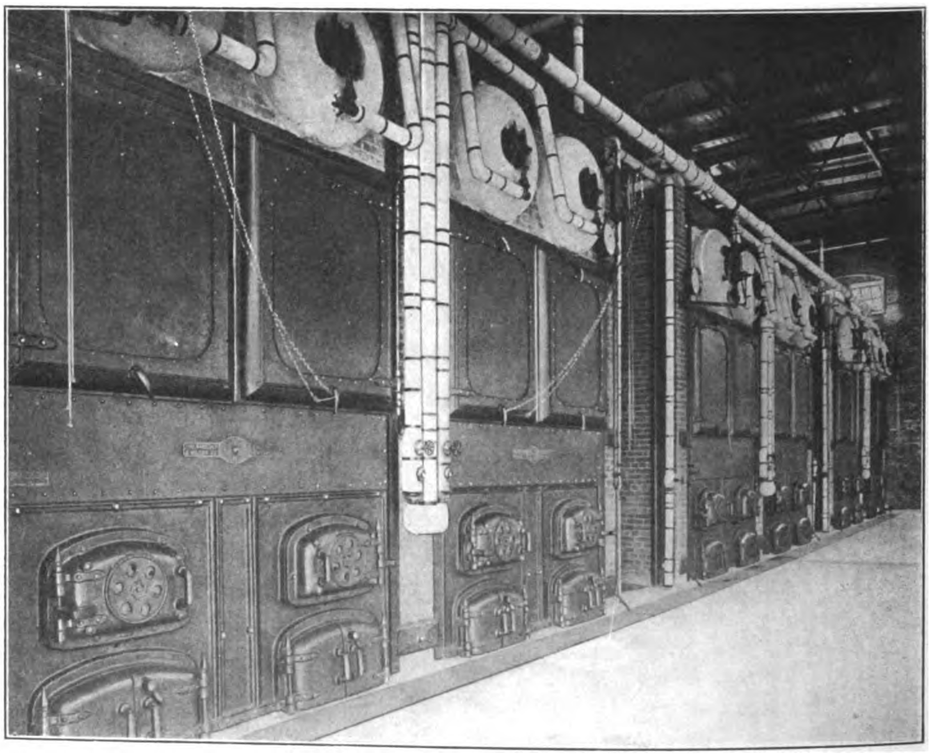


FIG. 6. GENERAL VIEW OF BOILER ROOM.

The boiler plant consists of six Babcock & Wilcox water-tube 300-h.p. boilers, set in three batteries. These boilers are equipped for burning oil, and the engineer of the plant states that even at the present high price of oil, it is a much cheaper fuel than coal. But one fireman is required on a watch, and he is also able to wash out his boilers and keep the boiler-room clean. The boilers carry a steam pressure of 140 pounds. They are connected by breeching to a brick stack which is 115 feet high and 9½ feet in diameter. In the engine-room there are installed three direct-connected alternating-current units for supplying the induction motor load, and a direct-connected direct-current unit for the direct-current motor load and the lighting. The engines which drive the alternators are of the cross-compound Buckeye type. They have cylinders 16½ and 30½ inches in diameter, with 30-in. stroke, the speed being 150 r.p.m. The generators driven by these engines are 300-kw. 25-cycle alternators, generating three-phase current at 480 volts. For exciting current there are installed two 125-volt 20-kw. exciters directly driven by General Electric marine type engines. The direct-current generator is driven by a tandem-compound McIntosh & Seymour engine, with cylinder divisions of 15 and 23 by 17 ins. The unit has a speed of 200 r.p.m., and the generator is a 160-kw., 250-volt machine. This direct-current genera-

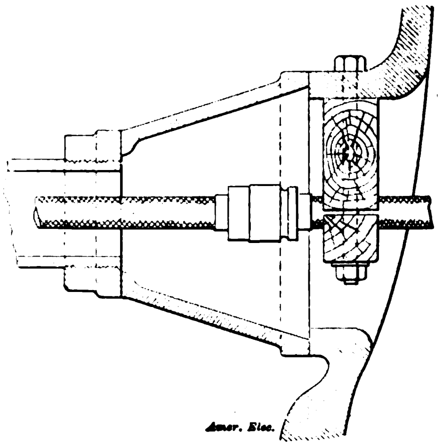


FIG. 7. CONNECTION BOARD.

tor, besides supplying the power for the shipping conveyors, furnishes the lighting load, which consists of 100 incandescent lamps on the docks and 400 in the elevator and power house, and twenty 220-volt enclosed-arc lamps for general lighting on the wharf.

There is also installed in the engine room one 150-kw. rotary converter, which generates a 250-volt current on the direct-current side, and is fed with 75-volt alternating current that is taken from a 165-kw., three-phase transformer located in the basement of the building. This rotary was designed to take the place of the direct-current generating unit whenever possible, and, during the day when there is no lighting load and when the alternating current is being used for the elevator motor service, it has been found advantageous to run the rotary on alternating current to generate the direct current for the conveyor motors on the wharf. This permits the direct-current generating unit to be shut down in the day time. Figs. 1, 3 and 5 are views in the engine room.

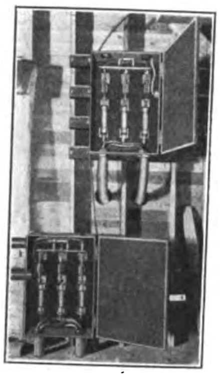


FIG. 8.—CUT-OUT BOX.

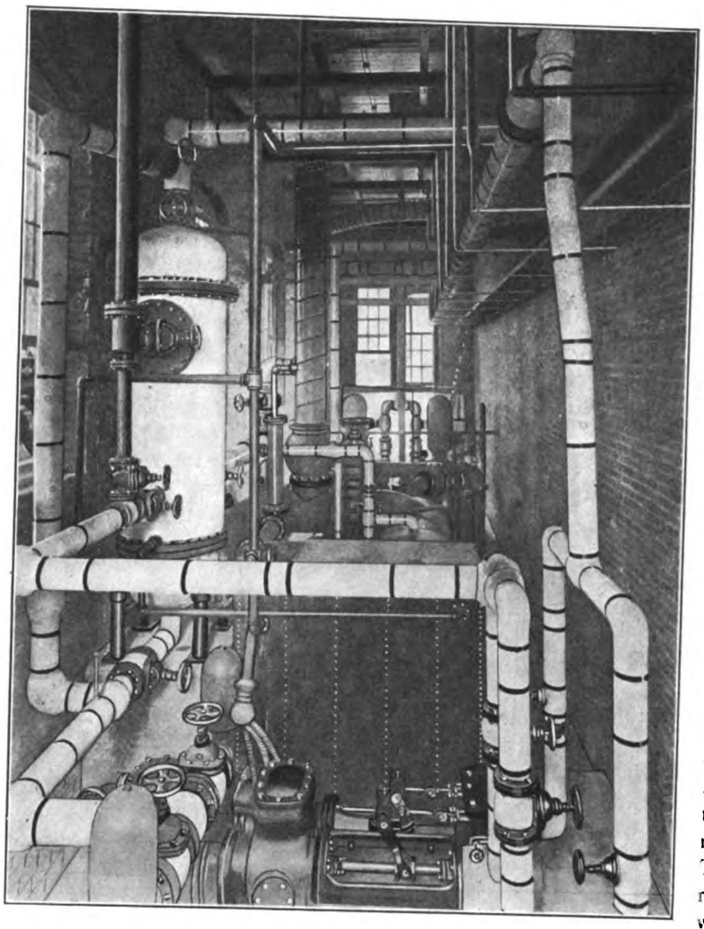


FIG. 10.—PUMP AND CONDENSER ROOM.

Fig. 1 shows the engine side of the generating units with the tandem-compound engine driving the direct-current generator in the foreground. Fig. 3 is a view of the generator side of the units, the direct-current machine being shown in the foreground at the left. Each of these views illustrates the truss construction of the roof, and shows the 15-ton traveling crane that spans the engine room. In Fig. 5 are illustrated the rotary converter and two exciter units.

The switchboard in the power house consists of ten panels of black slate, and is of the General Electric Company's standard manufacture. At the left are the exciter panel and three alternating-current generator panels. Then come two alternating-current feeder panels, each equipped with switches and instruments for two sets of feeders. The next two panels are for the rotary converter, one controlling the alternating-current side and the other the direct-current side. The ninth panel controls the direct-current generator and the last

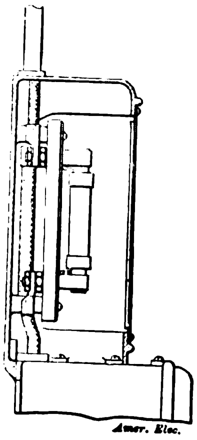
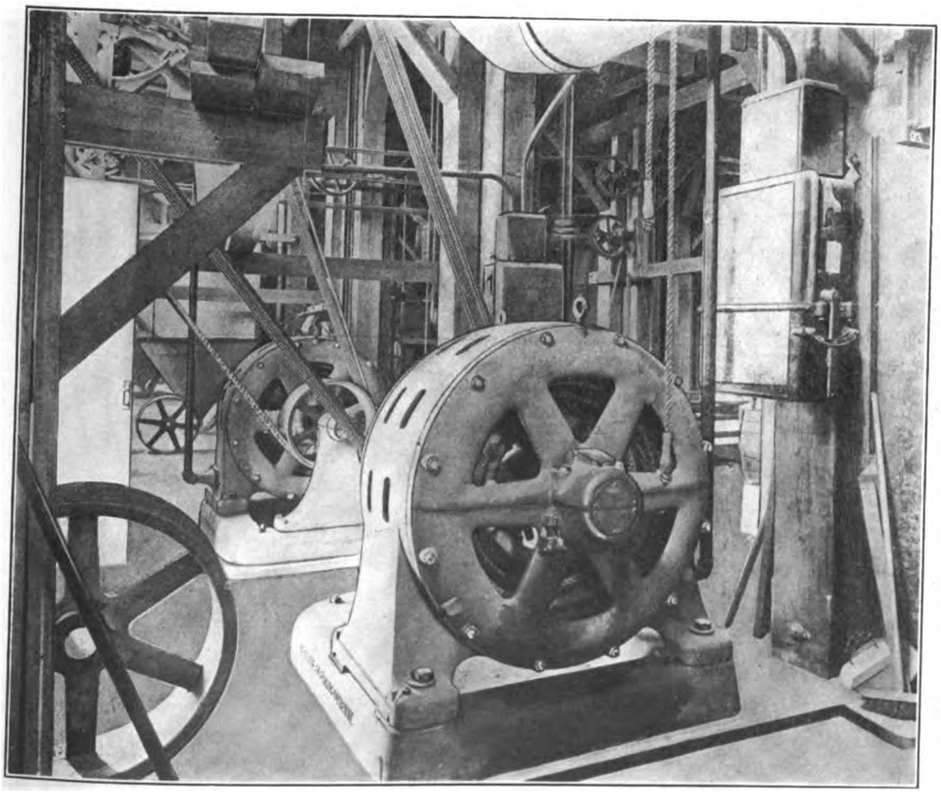


FIG. 9.—FUSE CASING.



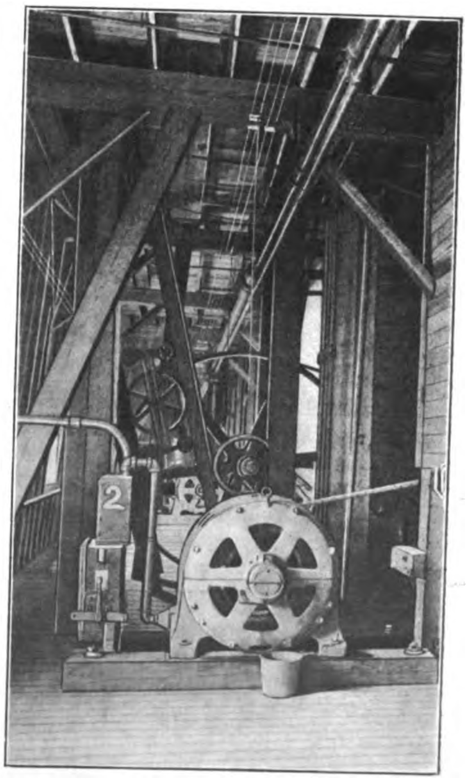


FIG. 11.—INDUCTION MOTORS DRIVING GENERAL MACHINERY; SHOWING ALSO THE FUSE BOXES AND STARTING COMPENSATORS.—FIG. 12.

one is provided with two sets of direct-current feeders, one for the dock motors and the other for the lighting. Mounted on a swinging bracket at the right of the board is a ground detector, and on the wall and in the rear of the switchboard is a starting panel for the rotary converter.

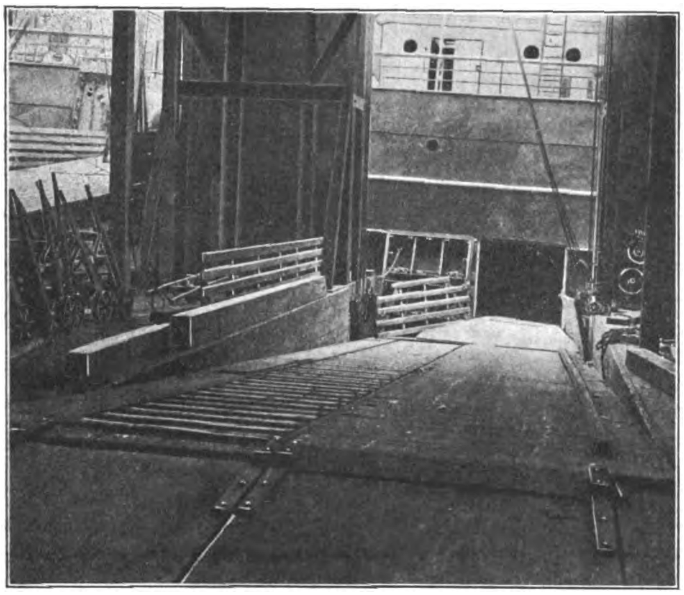


FIG. 13.—ELECTRICALLY-OPERATED FREIGHT CONVEYOR ON WHARF.

The wires from the switchboard are carried up in the rear of the board and then through the ventilator in the roof of the engine room to the pole line. Figs. 1 and 3 show the wires entering the ventilator. As stated, all motor wiring throughout the elevator is run in heavy iron conduit, but the light wires are run open.

In the pump room between the boiler and engine rooms there are installed two Snow outside-packed plunger duplex boiler-feed pumps, a hot well and a filter and an 800-h.p. Goubert vertical feed-water heater, into which the pumps and the exciter engine exhaust.

Each of the three Buckeye compound engines exhausts into a larger Wheeler surface condenser which is provided with a direct-connected centrifugal circulating pump and a Blake-Knowles vertical air pump. Two 1000-gal. Worthington underwriters' fire pumps are connected to a very complete sprinkler system which is installed throughout the elevator. There is also a smaller Wheeler surface condenser with combined steam-driven air and circulating pumps. Circulating water for the condensers is taken from Galveston Bay, and is, therefore, salt water. For the system of fire protection throughout the elevator salt water is also used. The fresh water supply for feeding the boilers is taken from the city water works system. As surface condensers are used, most of the water from the exhaust is saved and used over again in the boilers.

The John S. Metcalf Company, of Chicago, did the engineering and general designing of the elevator and power house, and C. C. Moore & Co., of San Francisco, put in the engines and steam equipment. L. L. Summers & Co., of Chicago, were the contractors for the entire electrical installation, and this part of the work was put in under the immediate supervision of N. P. Jensen, superintendent. Fred A. Jones, of Houston, Texas, was consulting electrical and mechanical engineer on the work. All the generators, motors, switchboard, signal bells and some of the electrical eqipment was supplied by the General Electric Company. The conduits, cutout boxes and switches were manufactured by the Karas Electric Company, of Chicago. The powerhouse and electrical equipment of the plant is now in charge of J. L. Durland, chief engineer of the Southern Pacific Terminal Company. The entire plant was laid out by G. W. Boschke, who is on the chief engineer's staff of the Southern Pacific Company.

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GENERATING EQUIPMENT FOR ISOLATED PLANTS.

BY PAUL C. PERCY.

Although generalizations are usually regarded with scorn by all specialists, there are some generalities which are so fundamental in character as to make their consideration profitable. This is no less true in the matter of isolated plant equipment than in any other line of work. It is, for example, fundamentally true that the generators of an isolated plant should be direct-driven when space is restricted, as in the case of an office building plant, but are preferably belt-driven when there is ample room for belts. While advocates of direct drive naturally consider belts an unmitigated nuisance, it is the writer's belief that most impartial engineers consider belted generators preferable when all of the controlling conditions of operation are favorable. The initial cost is considerably lower, and, other things being equal, the maintenance charges are less, for belted units than for coupled ones. Moreover, a plant of several units is far more flexible. An actual case in point, though admittedly involving extremely unusual circumstances, may be of interest. An office building plant consisted of three direct-connected units, two of equal size (100 kilowatts each) and one of 60 kilowatts output for the small-load periods. One of the 100-kw. generators became disabled by some trivial accident, and in starting up the second one hastily to take its place, water was entrapped and cracked the cylinder head. Of course, the "old reliable" central station service was utilized during the repair period, but with belted units the use of outside service might have been restricted to a few hours by shifting the good generator over in line with the good engine.

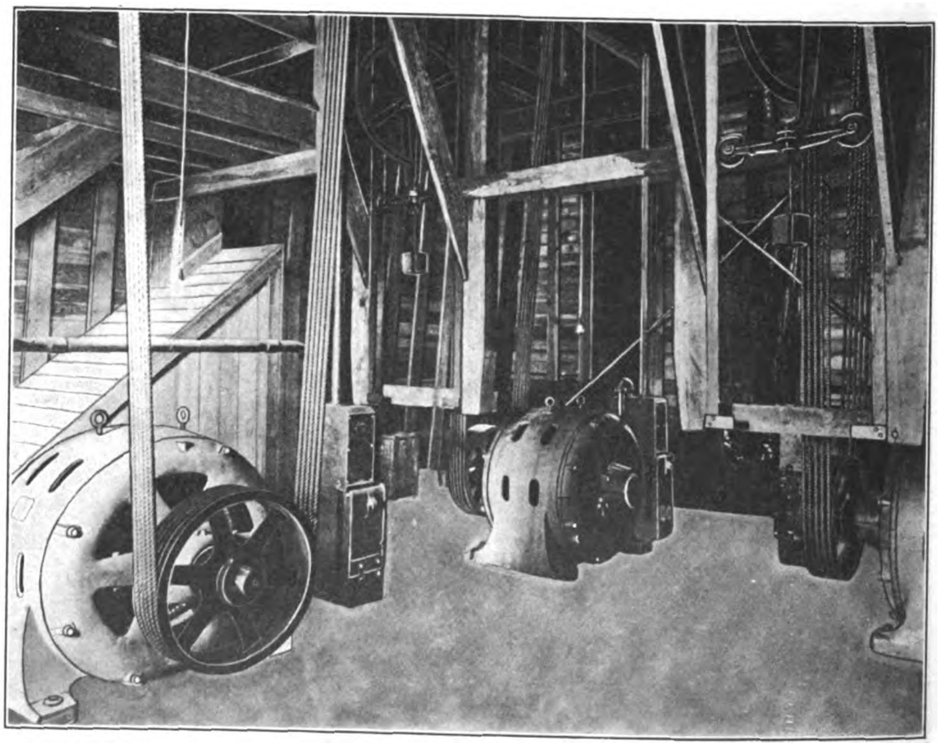

FIG. 14.—INDUCTION MOTORS DRIVING BELT CONVEYORS.

As stated above, this was a most exceptional case, but there are many combinations of circumstances possible that might make it profitable to be able to shift generators about. Of course, there should be no breakdowns, and, therefore, no possibility of needing to substitute generators, but this is another case of "a condition, not a theory."

The determination of unit sizes is largely a question depending upon the conditions of operation in each case. On general principles it is best to have all units of the same size and interchangeable, for obvious reasons. In plants of 300 kilowatts and over this is feasible and thoroughly practical; no plant should retain fewer than two units, unless it is so small as to make the units uneconomically small. A 100-kw. unit is of very good over-all efficiency, and even a 75-kw outfit is of high enough efficiency to justify the use of two units of this size rather than one of twice the output. The writer knows of at least one consulting engineer who makes it a rule to limit the number of generating units to two as a minimum and four as a maximum, making his choice within this short range, according to the individual conditions of each plant. The rule has worked well; all of his installations are well balanced, provided with interchangeable equipment, and show excellent operating economy.

As to the kind of engine and generator to be installed: this is also usually a case of "according to local conditions." In the large majority of cases high-speed automatic engines up to 200 or 250 horse-power and moderate-speed engines above are generally preferable, whether the units be belted or coupled. The generators, in the writer's opinion, should invariably be 240 or 250-volt machines. If the load consists wholly or chiefly of lamps, 250-volt dynamos with motor balancers and three-wire distribution are simpler and more satisfactory generally than either 250-volt, two-wire distribution or three-wire distribution with 125-volt dynamos. The motor balancers, however, should regulate inherently for equal voltages on each side of the neutral wire *at the center of distribution*, and not merely produce a rough approximation to equal division of voltage at the switchboard.

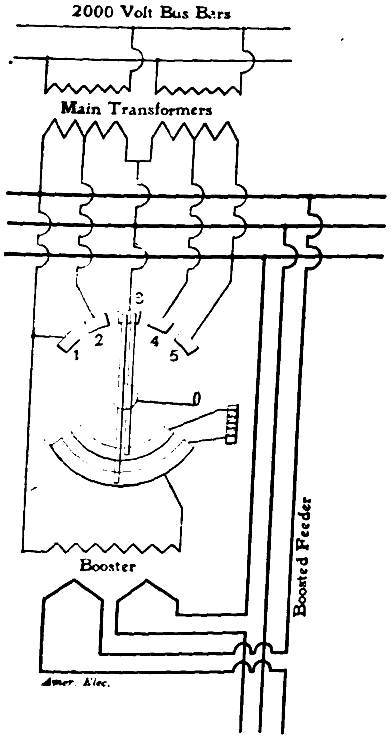

FIG. 1. THREE-WIRE BOOSTER CONNECTIONS.

It is scarcely necessary, in conclusion, to say that for all isolated or private lighting or power plants direct-current equipment is immeasurably preferable to alternating, unless the plant be a mammoth one, distributed throughout a large number of buildings which cover an abnormal area of ground. Even in such a case the writer's preference would be for direct-current apparatus, but there might be operating conditions which would make it advisable to consider alternating-current distribution.

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A SIMPLE ALTERNATING CURRENT BOOSTER.

BY F. B. O'HANLON.

Of the many improvements in electrical distribution during the last ten years, one of the most striking has been the suppression of the large number of small isolated transformers delivering currents at 50 volts or thereabouts. That this is an advance is shown by the fact that in many cases a very considerable increase in secondary output has been rendered possible without any increase in primary current, by installing large transformers in sub-stations and by the use of 100 to 500 volts on the secondary side, owing to the smaller all-day currents and higher efficiencies of the larger transformers. This grouping of transformers in sub-stations has, of course, led to a corresponding increase in the length of secondary feeders, and in laying out feeder systems it is often found that a large amount of copper must be put down for a particular feeder of considerable length in order to avoid an excessive drop, even though the maximum load is only on for a very small portion of the year.

In such cases it may happen that the interest and depreciation on the extra copper required is out of all proportion to the service rendered, and it will pay better to install only sufficient copper to take the average medium load of the light portion of the day or year, and to supply the volts which would be dropped at times of heavy load by means of a booster. Variable-ratio boosters suitable for the work can, of course, be obtained from many makers, but if some of the above-mentioned discarded transformers are at hand they can be taken off the scrap heap and made to render excellent service as boosters, and at a very small cost by following a method worked out by the writer.

As an example a case from actual practice is given. It occurred in laying out a large new sub-station which was to take the place of a number of small ones. The old sub-stations were retained simply as feeding points, and certain considerations made it necessary that the maximum drop to the nearest one should not exceed 2½ volts across the outer wires of the system, which was of the single-phase, three-wire class, distributing at 110 and 220 volts. For uniformity of service it was decided to work out the drop for all the feeders at this voltage, and on doing so it was found that the copper required for the outer wires of the longest feeder came out at 0.75 square inch each. The mains had to be triple-conductor concentric, lead-covered, and as the maximum load on the feeder was only 180 amperes per side, it will be readily seen that the cost of such a feeder would have been excessive when it is considered that the maximum load is only on for an average throughout the year of about 1½ hours per day.

A scheme was then worked out for a drop of 7½ volts on this feeder, 5 volts of which were to be supplied by a booster and the other 2½ volts by the general increase of main pressure at full load. This brought the copper for the outer wires down to 0.25 square inch each, which was a more reasonable figure.

An old shell-type transformer core was wound with a primary suitable for a maximum of about 220 volts, and with two secondary coils giving 2½ volts each, the latter being connected into the outers of the three-wire feeder, as shown in Fig. 1. The primary is shown connected up to the secondary windings of the main transformers through a switch which is used for varying the voltage of the current supplied to the primary of the booster. Since the voltage in the secondary windings is at all times proportional to the voltage in the primary, any variation in the latter will be followed by a proportional one in the former. The switch used is much like a storage battery regulating switch; the moving bridge being divided into two insulated arms between which a choking coil is connected, as shown. The arms are spaced so as to bridge the contact gaps and thus maintain a closed circuit while the composite arm is being moved from contact to contact. The choking coil is to prevent the short-circuiting of the main transformers, and it also prevents a sudden jump in the e.m.f., and as it is only in circuit while the bridge is passing over the gaps, it is of small and simple construction, practically no allowance for heat dissipation being necessary.

It will be noticed that when the switch is moved to No. 1 contact it short-circuits the primary of the booster and at the same time breaks the supply of current to it. This position is used when no boosting is required, and the object of short-circuiting the winding is to prevent the secondary from acting as a choking coil, and for another reason to be mentioned.

It is not necessary to short-circuit the secondary winding, since the loss by running through it will be practically only that due to the resistance, under the above conditions, and this is very low. And it is to be noted that no damage will be done to the primary winding by the current induced in it by the secondary, as the current in one winding of a transformer is proportional to that in the other, and if the current through the secondary does not exceed its proper value the current in the primary will not do so either. By moving the switch from contact to contact any value from zero to the full "boost" can be obtained in steps of 1¼, 2½, 3¾ and 5 volts. Of course any other values could be obtained if required. Most transformers now are provided with divided windings for working at different voltages, and even when they are not there is little difficulty in tapping them to obtain the necessary primary steps; this is especially true with the modern "fan-ended" coils.

Before proceeding to work out a design it will be well to mention the losses which occur in transformers, for it is these which fix the practicable output in any particular case. The copper losses are, of course, due to the primary and secondary resistances, and are equal to $I^2R + i^2r$ (the capitals representing primary and the small letters secondary quantities), and, therefore, decrease rapidly with the load. The iron losses are, perhaps, the more important in the case of constant potential transformers, since they are practically constant for all loads if the frequency is fixed. They are made up of hysteresis and eddy currents. Hysteresis is directly proportional to the periodicity for constant flux values and ordinary frequencies. It is not, however, proportional to the flux for constant periodicity, but varies as the 1.6th power of the flux density in the core.

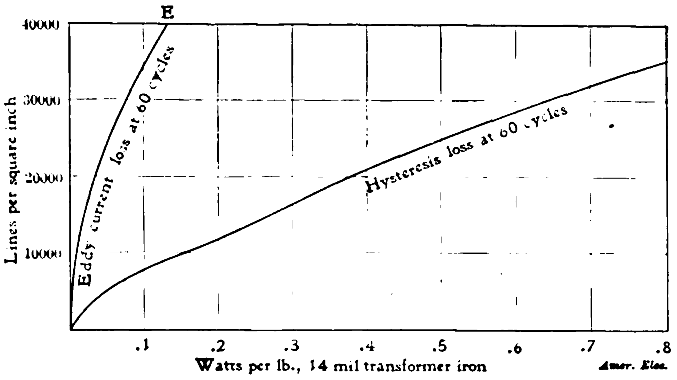

FIG. 2. CURVES OF HYSTERESIS AND EDDY CURRENT LOSSES.

With a given e.m.f. applied to the terminals of a transformer, a back e.m.f. is set up which may be expressed by the equation

$$E = 4.44\, f\, t\, \Phi\, 10^{-8} \qquad \text{(a)}$$

where E = mean effective e.m.f.,

4.44 = the $\sqrt{\text{mean}^2}$ of a sine wave through one alternation.

f = the frequency.

t = the number of turns in the coil being considered.

Φ = the total core flux in maxwells,

10^{-8} = a coefficient used to reduce from the C. G. S. unit to the practical units of e.m.f.

This holds good for both primary and secondary windings, and it is therefore evident that with a flux common to both, the relative e.m.fs. will vary in proportion to the number of turns. It is also evident from the above equation that the values of f, t, or ϕ can be varied to any extent while keeping the e.m.f. at the same value. In practice f is constant, and in the transformers to be designed the e.m.f. will be varied by varying the value of Φ.

Consideration will show that boosters designed on this principle which have a good efficiency at full load and will have an equally good or better efficiency at light loads since the copper and iron losses will decrease with the load. Where the principle can be adopted it will be found superior to any in which the boosting is varied by cutting in or out coils, since all turns are always employed in keeping down the induction, and hence the iron losses.

It is proposed to rewind some old cores which will therefore have fixed dimensions, and hysteresis losses which may be fairly represented by the curves in Fig 2. The curves are taken from transformer iron 14 mils thick and about 10 years old. Much better results can be obtained from the sheet steel now so largely used for transformers, but all calculations will be worked out from the curves given.

The first case is that of a transformer intended for a frequency of 100. It is to be rewound for converting from 230 volts to a maximum of 200 volts at 30 amperes, on either side of zero, for use as a high-tension booster on a 60-cycle system.

The core is of the "core" type, and the dimensions are as shown in Fig. 3. The gross area of the magnetic circuit is $3.5 \times 8.75 = 30.625$ square inches, but it will hardly be found possible to get all the iron back again, so to allow for this and the insulation between the plates the net cross-sectional area will be taken at 0.8 of the above or 24.5 square inches. The flux for the full voltage might be allowed to go up to an induction of about 40,000 lines per square inch, but it will be better to assume a lower value, say 25,000, and calculate the number of turns required. This can be found from equation (a). It will be more convenient to calculate the primary winding first; $E = 230 = 4.44 \times 60 \times 25{,}000 \times 24.5 \times t \times 10^{-8}$, so that

$$t = \frac{230 \times 10^8}{4.44 \times 60 \times 25{,}000 \times 24.5} = 140.$$

The copper for the winding will be rated at 1300 circular mils per ampere. A trial calculation will show that the above number of turns of a conductor having the required area will not work in without wasting space; taking the number of turns at 160 to fill the space, and working back to find the corresponding induction, Φ,

$$\Phi = \frac{230 \times 10^8}{4.44 \times 60 \times 160} = 539{,}602, \text{ and}$$

$$\frac{539{,}602}{24.5} = 22{,}000,$$

which is the magnetic density in lines per square inch.

At this induction the loss by hysteresis per pound of iron is 0.43 watt. The core measures $27 \times 3.5 \times 8.75 \times .8 = 661$ cubic inches, and a cubic inch of transformer iron may be taken at 0.28 pound, so the core will weigh 185.22 pounds. The total loss by hysteresis therefore will be $185.22 \times .43 = 79.6$ watts. The corresponding eddy current loss as found from the curve given, is 7 watts, making a total iron loss of 86.6 watts. The primary current to make **good** this loss will be

$$\frac{86.6}{230} = .37 \text{ ampere.}$$

The winding will consist of two coils wound next to the iron and placed one on each side, as shown in Fig. 3. A rectangular copper strip $.225 \times .125$ inch has a sectional of .028125 square inch or

$$\frac{0.028125}{0.7854} \times 10^6 =$$

35,808 circular mils, which is about the section required. It will be covered with an insulation adding 25 mils to the dimensions given. This will bring the overall dimensions up to 0.25×0.15 inch, which can be wound into 20 turns per layer and 4 layers per coil. A strip of insulating cloth 10 mils thick should be placed between each layer. The insulation between the windings and the iron should be 0.2 inch thick, and a small clearance space must be allowed to permit of the free insertion of the plates. This need not exceed ⅛ inch. The length of a mean turn will be 28 inches, which multiplied by 160 gives about 375 feet for the total length. If we assume that the copper will reach a maximum temperature of 45 degrees Centigrade we may take the resistance at 11.5 ohms per circular mil foot. The resistance of the winding will then

$$= \frac{\textit{length in feet} \times 11.5}{\textit{area in circular mils}}$$

$$\text{Resistance} = \frac{375 \times 11.5}{35{,}808} = .12043 \text{ ohms.}$$

The total primary current is 26.45 amperes, so the primary copper loss is $26.45 \times 26.45 \times .12043 = 84.25$ watts.

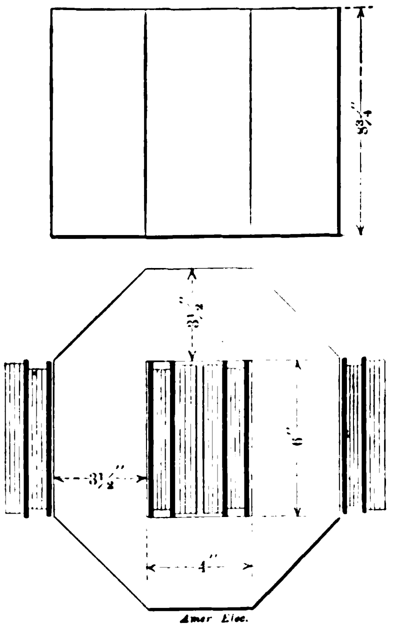

FIG. 3.

The number of secondary turns found from the ratio of the voltages is 139.13, but as this is not a practicable number, and there will be a voltage drop in any case, the number will be taken at 140, divided into two coils of 70 turns each, and wound over the primary. Owing to the better cooling effect of the outside position, the copper may be rated at the higher density of 1200 circular mils per ampere. At this rating a sectional area of 36,000 circular mils will be required. A strip .27 inch x .11 inch will have a sectional area of .0297 square in., or $\frac{.0297}{.7854} \times 10^6$ = 37,815 circular mils, which is near enough for the purpose. It should be double covered with 15 mils of cotton, adding 30 mils to the bare dimensions.

This strip (.3 × .14) can be wound into 18 turns per layer in the available space of 6 inches, so three layers of 18 turns and one of 16 will give the required number, per coil. A strip of insulating cloth similar to that used for the primary should be placed between each layer, and the insulation between the primary and secondary windings should be made ¼ inch thick, as it must be capable of withstanding the full voltage of the system on which the booster is to be used. Both sets of windings must be kept well clear of the iron at the sides, a sheet of insulating material should be inserted between the two secondary coils where they come together, and the terminals and connections must be insulated for the full voltage of the system.

The length of a mean secondary turn is 32 inches, and with 140 turns the total length will be about 375 feet. The resistance will be

$$\frac{375 \times 11.5}{37{,}815} = .11{,}404 \text{ ohms.}$$

The full load current is 30 amperes, consequently the watts wasted will be $30^2 \times .11{,}404 = 102.6$, so that the total watts lost at full load will be 273.45. This amount of energy will, of course, be converted into heat which will have to be got rid of by one of the usual methods. Transformers in practice have from 3 to 10 square inches of cooling surface per watt to be dissipated. The former figure applies to oil-cooled transformers, and upon reckoning up the amount of surface in the transformer just designed it will be found that oil will be needed in order to keep the temperature down, but this will be no disadvantage, as the insulation will be much improved thereby. Four steps of 57.5 volts each might be used in the primary regulating switch, and if this is combined with a reversing switch, the transformer can be used either as booster or reducer; that is to say, it may be used either to add to or reduce the delivered e.m.f. The reversing switch must be arranged not to break the continuity of the circuit, and for obvious reasons it must be interlocked with the regulating switch in all but the zero position.

It is an important point to preserve the continuity of the primary circuit under all conditions. If it were opened while the secondary circuit was carrying a heavy current, all the current would be available for magnetizing the core, there would be a redistribution of potential in the circuit, and the volts between the terminals might reach a very high figure. This in itself would be very objectionable, as the booster would then be acting as a choking coil, and even if the rise in voltage did not break down the insulation, the core would get injuriously hot, owing to the excessive hysteresis loss. To prevent this a safety device has been worked out which automatically short-circuits the primary winding should the volts go above a certain limit. A diagrammatic sketch of this is given in Fig. 4. It is simply a laminated magnet provided with an armature which is ordinarily held away from the cores, but which short-circuits the booster primary when it is attracted, owing to an abnormal increase in volts.

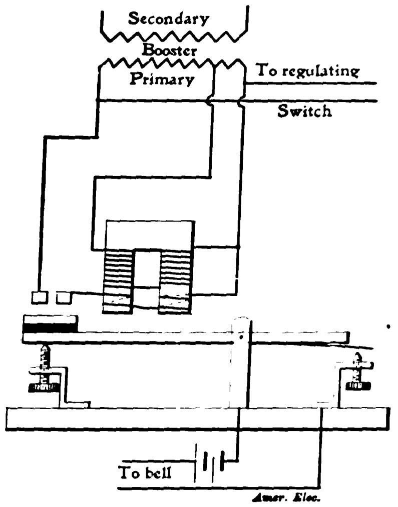

FIG. 4. SAFETY DEVICE FOR ALTERNATING-CURRENT BOOSTERS.

The magnet may be connected across a few turns only, or it may be wound for the full voltage of any of the coils. A few turns of series conductor of equal capacity to the primary copper should be provided, so as to hold the armature once it is attracted. The whole device is not much larger than an ordinary electric bell, and it may be combined with a warning bell, as shown, if desired. Of course, the use of such a device is optional.

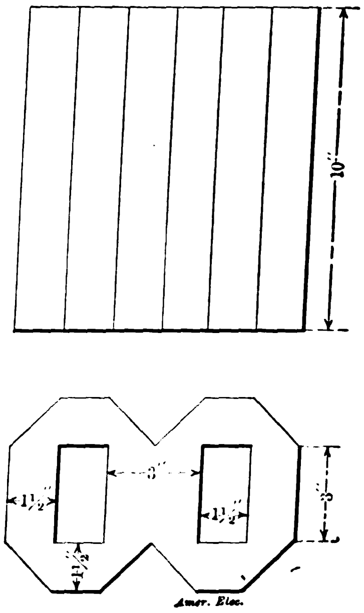

FIG. 5.

The full-load efficiency of the booster just worked out is 95.5 per cent. If it be assumed that the e.m.f. will be reduced in proportion to the current, when the latter falls to 15 amperes the secondary e.m.f. should be 100 volts, and giving an output of 1.5 kilowatts. The iron losses for this will be 35.5 watts, and the copper losses 43.25 watts or a total loss of 78.75 watts. The corresponding efficiency will be 94.8 per cent.

The next example is of a "shell" type, low-tension, three-wire booster; the dimensions of the core are as shown in Fig. 5. The output is 220 amperes at 6 volts; primary suitable for 105 or 210 volts; section of magnetic circuit = 3 inches × 10 inches × .8 = 24 square inches.

Cubic inches = 288. Weight of iron = 288 × .28 = 80.64 pounds. Limiting the allowable iron loss at full load to about 3 per cent or 40 watts, fixes the number of secondary turns at slightly over 4, because it fixes the magnetic density, and therefore the value of Φ. Taking the number at 4 the induction to correspond will be

$$\frac{6 \textit{ volts} \times 10^8}{4.44 \times 60 \times 4} = 563{,}063,$$

and the density will be

$$\frac{563{,}063}{24} = 23{,}460 \text{ lines per square inch.}$$

At this induction the hysteresis loss is 0.47 watt per pound, and the eddy current loss is 0.047 watt per pound; the total iron loss for the 80.64 pounds is therefore 42 watts. The ratio of transformation is 35 to 1, so 140 turns will be required for the primary winding. It will be divided into two coils of 70 turns each, which will be wound under the secondary and next to the core. The primary current to make good the iron loss will be $\frac{42}{210} = .2$ ampere, which, added to the current for the load, gives a total current of 6.28 amperes. No. 11 B. & S. wire will safely carry this current. It has an area of 8,233.7 circular mils, and when double cotton covered should be .103-inch diameter.

It can be wound into 12 turns per layer in the available space of 1.5 inch while leaving room for insulation and clearance. Five layers of 12 turns and one of 10 will be used for each coil. A strip of oiled paper 0.004 inch thick should be used between each layer, and the completed coil should be wrapped with 0.03-inch tape, adding .125 inch to the coil dimensions. The length of a mean turn will be 27.5 inches, and the total length of 140 turns will be 322 feet. The resistance will be

$$\frac{322 \times 11.5}{8{,}233.7} = 0.449 \text{ ohm.}$$

and the I^2R loss at full load is 18 watts. For working at 105 volts the primary coils are, of course, to be connected in parallel.

For the secondary each coil will consist of two strips of No. 13 B. & S. copper 1.25

inch wide wound in parallel. They should be taped together with a 0.02-in. tape, adding .08 inch to the thickness. Two turns per coil. Section of composite strip = 1.25 × .144 = .180 square inch.

Area in circular mils

$$= \frac{.180}{.7854} \times 10^6 = 229,182.$$

Total length of secondary copper = 12 feet.

$$\text{Resistance} = \frac{229,182}{12 \times 11.5} = .0006021 \text{ ohms.}$$

A strip of cloth 0.01 inch thick should be used between the turns, and the coils should be taped up with strong tape, adding 0.1 inch.

Secondary copper loss at full load = 29 watts, and this added to the loss in the primary and in the iron, gives a total loss of 89 watts, and an efficiency of 93.2 per cent. At half e.m.f. and current the loss will be 23 watts, and the efficiency 93 per cent. In this transformer the total surface available for the dissipation of heat is about 380 square inches, or about 4.27 square inches per watt.

The two examples given will serve to illustrate the general method of calculating designs. Various constructional details have been omitted, as they will suggest themselves to anyone likely to undertake the work.

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THE PRODUCTION AND DISTRIBUTION OF ALTERNATING CURRENT FOR LARGE CITY STREET RAILWAY SYSTEMS.

BY RICHARD M'CULLOCH.

The question of street railway power plants and distribution in large cities is the most difficult of solution, and in taking it up several plans suggest themselves: (1) To keep the best of the present plants, add to them as necessary, and adjust the distribution systems from them. (2) To abandon the present plants, constructing an entirely new plant with a new distribution system leading from it, using the old plants as sub-stations if they are suitably located. (3) A combination of these two systems, which consists in the beginning of a new plant, the plans of which contemplate the operation of the entire system from it at some future date; at the present time, however, only putting enough apparatus in the station to take care of the growth of the system and adding to it from year to year as other stations are abandoned.

The great and all-important question which confronts the manager, and which the engineer should assist him in solving, is how to transport passengers with the greatest degree of safety, reliability and economy. The power plant and transmission system constitute only two links in the chain of many devices necessary to accomplish this task, and should not be given undue importance in the laying out of the general scheme. Economy of generation or transmission of power should never be sought after at the expense of safety or reliability of operation.

In this paper the alternating current will be considered to be made by steam power at a central station, transmitted at a high voltage to sub-stations located in different parts of the territory to be served, there converted into 575-volt direct current and distributed by means of feeders to the trolley sections in the usual way. The use of alternating-current motors for street cars, although the subject of a great deal of experimenting has not yet been successful. Where the stops are frequent, as in the case of city service, in the present state of the art the use of alternating-current motors is impracticable.

For railway and power transmission work the advantage of transmission by alternating current is that small high-tension feeders from the central station and short direct-current feeders from the sub-stations are substituted for the long, heavy lines of feeders leading from the central direct-current station. The problem is more one of current transmission than of current production.

Site of Station.—The central station should be located where coal may be obtained by rail or water, or both, and where large quantities of water may be obtained for condensing purposes. If a location fulfilling these requirements can be obtained in any large city near the centre of gravity of the load, well and good; if not, it is not so serious as it would be if the plant were designed to furnish direct current. The location should not be in a residence district, where the plant is apt to become a nuisance, and physical obstacles to the laying of feeder mains, such as rivers, bridges, etc., should be avoided if possible in the selection of the site. In the general principles of its construction the alternating-current plant does not differ from the direct-current plant, except that the amount of power installed and the size of the units usually warrant a magnitude of construction rarely attempted in direct-current plants.

Coal Supply.—There is no point more important to the continuous operation of a power plant than the delivery of coal. The amount of coal coming to one of our large power plants is such that extraordinary means must be taken for quickly unloading and handling it. If the coal is delivered by rail a large switch yard must be provided for handling the cars, and if bottom-dumping cars cannot be depended upon some form of car tipple for quickly unloading should be installed. The tipple used on the ore docks suggests itself for this purpose. If coal is delivered by water, clam-shell drop buckets are used for unloading the barges. Experience has shown that one must expect at times to be obliged to burn all sorts of coal in all sorts of conditions. It is, of course, preferable that the coal should be delivered crushed ready for the automatic stokers, but provision should be made in the layout of the station for a coal-crushing plant to handle lump coal and mine-run coal. The quantity of coal burned in the large stations is such that if an attempt is made to furnish storage capacity within the plant for even a modest period of the time, the size and cost of the building are enormously increased by the large coal tank perched high in the air above the boilers. It is perhaps a better plan, if the location of the power plant permits, to carry only a few days' supply in the tank in the boiler room and provide a separate building for the coal reserve, connected by conveyors to the boiler room, where the coal may be kept nearer the ground and the cost of the iron work for its storage diminished. A plant should be laid out for the kind of coal it is intended to burn, and in cases where the cities are located so far from the mines that the cost of transportation becomes a large factor in the cost of the coal it would pay to devote a great deal of attention to a determination of what is really the most economical coal to burn and not assume, as is so often done, that that coal is best which can be had for the lowest price per ton.

Coal and Ash-Handling Machinery.—The apparatus for handling the coal and ashes of a large power station constitutes a formidable plant in itself. It is perhaps better in a larger installation to keep the coal and ash handing apparatus independent, as ashes are much more abrasive than coal, and it is better to leave either set of apparatus free so that it can be used at any time.

Mechanical Stokers.—The use of mechanical stokers in the large plants of today is universal. They are much more efficient on low-grade fuel and by their use and that of coal and ash handling machinery the employment of a large number of laborers in the boiler room is dispensed with. In fact, if it were necessary to handle the coal and ashes and fire the boilers by hand it would be difficult to get men enough into some of our large plants to keep them going, and these men would be a constant source of annoyance.

Boilers.—Some form of water-tube boiler is usually chosen for large plants because it may be made in large sizes without danger of explosion, and occupies less ground space per horse-power than the fire-tube boiler. There is nothing remarkable about the boiler installation of an alternating-current plant, except that the size of the plant and the size of the units is such that a two-story boiler room is usually required.

Engines.—Until quite recently, the only prime mover for driving generators of large size in railway steam plants was the compound condensing steam engine. The triple expansion engine has been used in no large installation. In one recent installation a duplex compound engine, with the two low-pressure cylinders horizontal and the two high-pressure cylinders vertical, drives the generator. This is a mammoth unit of 5000 kilowatts and is the largest which has been built.

Turbines.—Of late years, however, improvements in manufacturing facilities and increased knowledge of the properties of steam have made possible the utilization of the steam turbine. The steam engine has reached such a size that for large units it would seem that the limit for driving electric generators is about reached. If the claims of its advocates are only partly realized, the steam turbine is the ideal machine for driving alternating-current generators. The efficiency of the steam turbine is claimed to be fully equal to that of the best steam engine; the turbine being a rotary machine, the thrusts caused by the reciprocating motion of the steam engine are avoided, thus relieving the foundation and frame of that strain and facilitating the operation in parallel of alternating-current generators; foundations and buildings for turbines are cheaper than those for engines; as the electric generator is driven by the turbine at a much higher speed than by the engine, its cost is less; there being no valve gear and reciprocating parts in connection with the turbine, its maintenance is less, and there is no need of the skilled attendance during operation so necessary with the engine; as no oil is needed for the lubrication of the turbine. the steam may be condensed in surface condensers and used over again in the boilers, thus affording practically distilled water for boiler use. All of these claims are made for the turbine, and though all of them may not be fully realized it is likely that there will be such advantages in the use of steam turbines that no large alternating-current plant will be built in the future containing any other prime mover.

Superheated Steam.—The amount which steam may be superheated when used for driving steam engines is limited on account of the carbonizing action of the steam on the cylinder and valve lubricants. With a special valve gear constructed for use with superheated steam, steam superheated 150 degrees Fahrenheit above the temperature corresponding to its pressure may be used. With steam turbines any superheat which it is practicable to obtain may be used, and great economy is effected by its use.

Condensers.—In order to obtain the maximum economy by the use of steam turbines, as rare a vacuum as possible should be maintained by the condenser, the usual specification calling for twenty-eight inches. This necessitates a larger and more expensive condenser than is usually installed with the same capacity in steam engines. The economy of the steam turbine increases very rapidly, both with the quantity of superheat and the rareness of the vacuum, and the limit of twenty-eight inches has only been set because it is the limiting vacuum which it is practicable to maintain.

Steam Pressure.—Economy in the use of steam also increases the steam pressure. With compound condensing engines the common pressure in use is 175 pounds, while with steam turbines the economical point seems to be about 200 pounds.

Piping.—The design and installation of the piping in a large, higher-pressure plant necessitate the greatest degree of skill. The old fads of double-headers, auxiliary headers and loop systems have expired, and now the best practice is to make the piping as short and simple as possible, and make up in excellence of construction the security which it was once sought to obtain by doubling the installation. In some of the large plants recently installed, the condensers have been set directly over tunnels connected with the water supply and the heavy piping necessary for the condensing water has been entirely done away with.

Auxiliaries.—The auxiliary apparatus, such as coal crushers, coal and ash-handling machinery, stoker machinery, boiler feed pumps, condenser pumps, air pumps, cranes, exciters, elevators, etc. require a large amount of power for their operation, and the piping for the engines furnishing this power is expensive of installation and maintenance. It is recommended that these auxiliaries, as far as possible, be driven by motors, preferably induction motors. There will be a gain in economy over steam operation, and a large amount of high-pressure steam piping will be done away with. Any machine which should run at a reasonably constant speed can be operated by means of an induction motor, and one which requires a variable speed can be run with a direct-current motor.

For one large alternating-current plant, the construction of which is now pending, it is proposed to furnish current for the auxiliaries and for the excitation of the generators as follows: Small alternating-current generators, driven by turbines, are to be installed to furnish current of a voltage suitable for driving all the induction motors in the plant. Rotary converters, driven by this current, furnish the direct current, probably at 250 volts, for exciting the main generators, and for lighting the plant. A storage battery installed on this 250-volt circuit steadies any fluctuations and furnishes a reserve in case of a breakdown. In this way the running of the auxiliaries, the excitation of the generators and the lighting of the plant are made entirely independent of the main current supply.

Division into Units.—Large alternating-current city plants as at present installed represent a vast quantity of power under one roof. Any accident which might cripple the plant would have very serious results, and affect a large number of people and industries. The greatest care should be taken to avoid such a possibility. In order to prevent, as far as possible, the crippling of the entire plant by an accident to any part of it, some of the more recent installations have been divided into units, each unit consisting of a generator, engine and condenser, together with the necessary number of boilers to furnish steam for the engines and the auxiliaries in connection with the boilers. It is intended that each unit shall be independent of any other; in fact, there will be as many separate power plants as there are units. An emergency steam connection is made between the steam headers, but for emergency use alone. The unit method minimizes the danger of a complete shutdown of the plant, but the price paid for it is the greater amount of reserve apparatus necessary, and also a somewhat poorer economy if the unit idea is carried out in detail as to feeders and sub-stations.

Frequency.—By common consent a periodicity of twenty-five cycles per second has been adopted in the United States for alternating-current power work. Rotary converters work better at low frequency, and in a combined railway and lighting plant where alternating-current lighting is to be done it is best to generate at twenty-five cycles, use rotary converters at this periodicity for the railway and direct-current lighting, and install motor generators to give a frequency of sixty cycles for any alternating-current lighting.

Phase.—Where the generator voltage is used in transmission, it is the accepted practice to generate three-phase current. Where the generator current is stepped up for transmission, it is the custom with some manufacturers to generate two-phase current and in stepping up the current for transmission to change it to three-phase. In most city installations the desired transmission voltage is less than 15,000, and as this voltage can be obtained with modern insulation in well designed generators, unquestionably the best practice is to generate at the transmission voltage, because this obviates the use of step-up transformers. Where the desired transmission voltage is above that which can be obtained in the generator, it is common to generate at a low voltage and raise the transmission voltage by means of step-up transformers.

Operation of Generators.—For railway and power purposes there is no great difference between the running of alternating and direct-current generators. If there is any difference it should be in favor of the alternating-current machine, owing to the substitution of rings for the commutator, and the slightly greater efficiency owing to the absence of brush friction and losses. The large modern machines are made of the revolving field type, the revolving parts carrying low-voltage current and the high-voltage confined to the stationary parts with little risk of accidental contact with persons. With engines of good regulation and similar types of valve gear there is no difficulty in running engine-driven alternating-current generators in parallel, and with generators driven by turbines which have a constant impulse throughout the entire revolution, operation in parallel becomes a simple matter.

Switches.—The handling of high-voltage current in large quantities is quite a serious question, and the switches and switching devices of a large alternating-current station have become one of the most important parts of the plant. In the more recent installations, the switch contacts are broken in oil and each switch is built in a brick fireproof compartment. The bus-bars are divided into several sections, so that in case of a short-circuit any section may be isolated. All switches are opened and closed by means of a motor running on an auxiliary circuit controlled by the switchboard attendant. No high-voltage current is brought to the switchboard.

Transmission Voltage.—In a few words, the advantages which alternating-current transmission offers lie in the possibility of transmitting large amounts of power over long distances with comparatively small wire. Since the size of the wire necessary decreases as the transmission voltage increases, there seems to be no reason why for city use, where heavy loads must be transmitted, the limiting transmission voltage should not be the limiting voltage at which current can be produced in the generator, except that voltages above 15,000 require cables of high cost. It is unquestionably the best practice to carry the high-tension cables underground in conduits. There are some large cities where alternating current at a pressure of 5000 volts is carried on overhead wires strung along the city streets, and although quite a sum of money is saved in the initial cost of feeders, the true economy of such an installation is doubtful. Serious interruption to traffic and perhaps injury to the central station and sub-station machinery are invited by short-circuits and grounds from fires, storms, lightning and accidental crosses with other wires, while the danger to human life is such that a railway company is liable at any time, on account of some fatality, to be ordered to place the high-tension wires underground at a greater expense than if it had been done in the first installation.

Transmission Cables.—As by three-phase transmission a minimum of copper transmits a given amount of power with a given loss, this is the system which has been adopted for transmission. Where the feeders are placed underground,, three-conductor cables are used, the three conductors being separately insulated and then surrounded by a lead sheath. Formerly rubber was the insulation used for this purpose, but paper has come rapidly to the front, and at present paper insulation is preferred by many to rubber. Paper is not softened under heat like rubber, and the cable has the advantage of being cheaper than the rubber and of having a somewhat greater overload capacity.

TABLE I.—RUBBER INSULATED LEAD COVERED, THREE NO. 00 CONDUCTOR CABLES

For three-phase, alternating current underground distribution. Cables to be carried in tile or concrete duct, one cable in each duct

Working Voltage	Outside Diameter of Cable	Thickness of Envelope of Each Conductor	Thickness of Envelope Around Conductors	Thickness of Lead Covering	Weight per Foot	Cost per Foot	Test Voltage for 1 Minute	Minimum Radius of Bending	Working Capacity Each Conductor Amperes per Sq. In. of Cross Section Temp. Rise, 30° C.
5,000	1 13/16 inches	3/32 inch	3/32 inch	3/32 inch	4.86 lbs.	$0.64	15,000	10⅞ inches	1,150
7,500	2 "	4/32 "	4/32 "	3/32 "	5.50 "	0.91	22,500	12 "	1,150
10,000	2 9/32 "	5/32 "	5/32 "	⅛ "	7.24 "	1.16	30,000	13⅝ "	1,150
12,500	2 15/32 "	6/32 "	6/32 "	⅛ "	8.27 "	1.37	35,000	14¾ "	1,150
15,000	2¾ "	7/32 "	7/32 "	⅛ "	9.29 "	1.62	40,000	16⅝ "	1,050
17,500	2 31/32 "	8/32 "	8/32 "	⅛ "	10.22 "	1.79	45,000	17¾ "	1,050
20,000	3 5/32 "	9/32 "	9/32 "	⅛ "	11.15 "	2.08	50,000	19 "	1,050

In estimating the sizes of cables for carrying the high-tension current it is usually necessary to figure the cable for ampere carrying capacity instead of for drop in voltage, as is customary in long-distance transmission. This is on account of the short transmission distances as compared with the high-transmission voltage. The amperes per phase for three-phase transmission may be determined very simply by dividing the watts to be transmitted by the transmission voltage multiplied by the square root of three.

The cross sections of the copper may be taken very conservatively at 1000 circular mils per ampere for rubber insulated cables and 900 circular mils per ampere for paper insulated cables. The copper cross section should be checked by estimating the drop in voltage at maximum load, but for the comparatively short distances of city work it will usually be found that the drop in voltage is very small in a cable properly proportioned for the current it is to carry. The largest size three-conductor cable which it is advisable to install in an ordinary duct is one in which each conductor has a 0000 section.

Tables Nos. 1 and 2 give data and cost of rubber and paper insulated three-conductor, lead-covered cables with 00 conductors, for voltages ranging from 5000 to 20,000. It will be observed that above 10,000 volts for rubber and above 15,000 volts for paper insulated cables the cost increases so rapidly as almost to make these the limiting voltages for underground distribution.

In some installations one cable for each rotary has been run between the power plant and the sub-station. In other instances a standard size of cable has been adopted for the system, and a number of cables run to each sub-station corresponding to the estimated load. An extra cable should always be provided, so that the maximum load of the sub-station may be carried with one cable out of service.

Conduit.—Several forms of duct have been used for underground conduits. The old wooden pump-log ducts have been abandoned because the wood rots and the juices in the wood act chemically on the lead covering of the cable. The ducts at present laid are usually of cement-lined iron pipe, tile in either single or multiple duct, and concrete tubes. It pays to imbed the ducts well in concrete, so that an excavation under the conduit line will not cause settling. The spacing of the brick manholes is usually determined by the obstructions met with in the street, but may be put down as averaging about 400 ft. apart. In some recent installations great precautions have been taken to avoid the danger of fire and damage to other cables, arising from a short circuit in one of the high-tension cables. The high-tension cables have been kept to themselves and at the manholes they have been wrapped with asbestos cloth. The destructiveness of a short circuit on underground high-tension cables has not proven as great as was anticipated. In one instance a laborer drove a pick through a 6600-volt three-conductor cable without experiencing any shock, or producing any great amount of pyrotechnics. It was fortunate for the laborer that the pick had a long wooden handle. The lack of destructiveness in the arc is probably due to the quick action of the automatic circuit breakers, and also to the fact that although the pressure is of great intensity, the current flow is small.

TABLE II.—PAPER INSULATED LEAD COVERED, THREE NO. 00 CONDUCTOR CABLES

For three-phase, alternating current underground distribution. Cables to be carried in tile or concrete duct, one cable in each duct

Working Voltage	Outside Diameter of Cable	Thickness of Envelope of Each Conductor	Thickness of Envelope Around Conductors	Thickness of Lead Covering	Weight per Foot	Cost per Foot	Test Voltage for 1 Minute	Minimum Radius of Bending	Working Capacity Each Conductor Amperes per Sq. In. of Cross Section Temp. Rise 35° C.
5,000	1⅞ inches	7/64 inches	7/64 inches	⅛ inch	5.5 lbs.	54.8 cts.	15,000	15 inches	1,150
7,500	2 5/32 "	5/32 "	5/32 "	⅛ "	6.52 "	61.6 cts.	22,500	17¼ "	1,150
10,000	2⅜ "	6/32 "	6/32 "	⅛ "	7.26 "	66.4 cts.	30,000	19½ "	1,150
12,500	2 9/16 "	7/32 "	7/32 "	⅛ "	8.04 "	72.9 cts.	35,000	20½ "	1,150
15,000	2¾ "	8/32 "	8/32 "	⅛ "	8.84 "	78.5 cts.	40,000	22 "	1,050
17,500	2 31/32 "	9/32 "	9/32 "	9/64 "	10.60 "	88.5 cts.	45,000	23¾ "	1,050
20,000	3 3/16 "	10/32 "	10/32 "	9/64 "	11.28 "	93.2 cts.	50,000	25½ "	1,050

Sub-Stations.—The location and number of sub-stations might form the subject of an interesting discussion as to the relative costs of interest on feeder investment, sub-station equipment and maintenance and operation of sub-station, were it not for the fact that for city use the location of the sub-stations is closely determined by a study of the density of the traffic. The congested points are closely marked, but where doubt exists as to the wisdom of several locations, an estimate of the costs in either case, together with the expense of maintaining and operating the sub-stations, will quickly determine which is the better plan.

In interurban construction there are two different opinions maintained regarding sub-stations. One is that sub-stations should be miniature power stations, contain a large quantity of apparatus, in charge of skilled attendants, and be spaced at rather long intervals along the road; the other idea is that sub-stations should be frequent, contain little reserve, and should be taken care of by the station agent or some other employee whose principal duties are not the caretaking of the sub-station. In city practice, however, there is no question but that the sub-station should be designed and built with as much care as that used in the power plant construction, that it should contain reserve apparatus enough to tide over any ordinary breakdown, and that it should be constantly in charge of skilled attendants.

The high-voltage current entering the sub-stations is handled by brick-enclosed oil-break, motor-operated switches, just as in the power station. From the switches it passes to transformers, where its voltage is decreased to that suitable for driving the converters. This current, fed in at the alternating-current end of the rotary converters, produces the 575 or 600-volt direct current which is sent to the direct-current bus-bar for transmission to the trolley wire. The transformers are cooled either by water circulating around the shell or by air blown through the windings.

Rotary Converters.—A size of rotary converter which has been largely adopted for city work is 1000 kilowatts, although one large installation has 1500-kilowatt rotaries. There seems to be no reason why rotary converters should not be built in as large sizes as direct-current generators, which have been successfully built in sizes of 2500 kilowatts. The rotary converter is just as reliable a machine as the direct-current generator, and there should be about the same reserve capacity in a sub-station as is allowed in a direct-current station; that is, one reserve machine to every three or four units. Where the load is subject to sudden fluctuations, it is customary to place a reactive coil in the transformers and provide the rotaries with series windings on the pole-pieces, in addition to the shunt windings. For city use rotaries have simple shunt fields, and if they are kept well loaded at all times, their direct-current voltage is uniform. The sub-station of a large city system has such a large output that the momentary fluctuations noticeable in a small system are lacking. The load varies with the time of day; the attendants usually have plenty of time to prepare for any change in load, and there is no reason why they should not keep the rotaries well loaded.

Storage Batteries for Sub-stations.—Storage batteries have been installed in many of the large sub-stations for the purpose of steadying the load on the rotary converters, taking care of the peaks of the load and creating a reserve capacity in the sub-station in case of a breakdown of the machinery. If it is possible, with any reasonable degree of accuracy, to draw the load curve for a proposed sub-station, the question of whether it is more economical to install rotary converters or storage batteries to take care of the peaks may be determined in advance. Most railway load curves show peaks in the morning and evening, some portions of which may be taken by batteries working up to their one-hour rate, provided the duration of the peaks is not too long. In case the shape of the peak is such that no portion of it is of shorter duration than three or four hours, the cost of a battery for handling it would probably be excessive. It should be taken into account that a sub-station battery carrying the peak of the load not only takes the place of a certain amount of rotary capacity, but exercises a valuable smoothing-out effect on the load, replacing an equivalent amount of station capacity at the central power plant; so that the investment in battery should be compared with the investment in rotaries, high-tension feeders and in generators and steam plant capacity thus dispensed with at the power plant. Figured at the one-hour discharge rate, the relative first cost of storage battery as compared with rotary converter, feeder and steam plant is approximately $90 per kilowatt for the storage battery and $130 per kilowatt for the converter plant, steam plant and transmission line, the latter figure being $30 for the rotary plant and $100 for the steam plant and transmission line. This estimate for rotary and steam plant is based on the nominal ratings of the machines and does not take into account their overload capacities. A battery worked on the peak at its one-hour rate is likely to cost about the same or somewhat less than the apparatus which it displaces.

The value of the storage battery as a reserve in heavy sub-station work depends upon the comparative amount of storage battery and rotaries which has been installed. If the sub-station contains a small amount of battery and a large amount of rotary, the reserve value of the battery is likely to be small; if, however, the short duration and sharp nature of the peaks have warranted a comparatively large battery installation, the battery may be of sufficient size to handle the entire load of the sub-station during the lighter hours of the day for a period long enough to tide over a breakdown, provided that this period is not longer than half to three-quarters of an hour. While the battery may replace those rotaries which would be operated for an hour or two on the peak, it cannot be depended upon to take the place of those machines which run throughout the entire day. The reserve feature of a storage battery is especially valuable because it may be put into service immediately and in this it has the advantage of the steam plant, where time is required to get boilers ready for steaming.

Low-Tension Switchboard.—The feeder board for the sub-station and the 500-volt feeders leading from it to the trolley sections are practically the same as those used in connection with a direct-current station, and all of the devices installed in the best direct-current stations for the detection and isolation of trouble on the trolley sections should also be placed in the sub-station.

The Relative Advantages of Alternating and Direct-Current Generation and Transmission.—With a desire of learning exactly what are the conditions in the cities of the United States, a circular letter was mailed to roads in all cities of more than 100,000 inhabitants. The information shows that the use of alternating current for city work is at present largely confined to the operation of suburban roads from city power stations. With the exception of New York, most of the other cities have a mixed system, direct current being used for city work and alternating current for suburban work. Brooklyn and Philadelphia are now building alternating-current stations, and Chicago will probably soon begin the change to alternating-current distribution. With the single exception of New York, all cities of more than 200,000 inhabitants have from three to eight power stations. Whether this condition is more economical or more desirable than distribution from a single power station is a problem which must be solved for each special case. The number of American roads using alternating current for purely city work is at present very small, but it is likely that within the next few years many city roads will change partially, at least, to the alternating-current system.

A discussion of the relative advantages of alternating and direct-current generation and transmission involves a discussion of the relative economy and reliability of generation and transmission, and the relative advantages of one and several power stations.

The transmission losses in the feeders and return circuit from a direct-current station depend entirely upon the quantity of copper which it is deemed advisable to put into the feeders. For a city transmission where the feeders are long, and where concentrated loads are likely to occur at long distances from the power station, the transmission losses are probably between 15 and 20 per cent at maximum load in a well-installed system.

In an alternating-current transmission, the losses at maximum load are likely to be about as follows:

High-tension feeders ...	3	per cent
Transformers	2½	per cent
Rotary converters	5	per cent
Low-tension feeders....	7 to 10	per cent

making a total transmission loss between the generator and the trolley wire of 17½ to 20½ per cent, which is about the same as that estimated for the direct-current transmission. From these figures it will be seen that if the generating plant in the direct-current station is as economical as that in the alternating-current station, alternating-current generation and transmission should be no more economical than that by direct current.

As to the relative reliability of alternating and direct-current transmission, the latter has many advantages, owing to its greater simplicity. In the direct-current transmission the current is sent straight from the direct-current switchboard to the trolley feeders, while in the case of alternating-current transmission, there are interposed in the circuit, in addition to everything required in direct-current transmission, the alternating-current switches, the high-tension feeders, the step-down transformers and the rotary converters. A failure of any piece of apparatus in this chain, or a mistake of any operator, is likely to cripple the system. With equal standards of workmanship and with an equal quality of operating skill in the two cases, the direct-current system would be the more reliable.

The real problem which confronts most railroad companies in large cities is the question of the substitution of an alternating-current plant equipped with modern machinery in large economical units to replace several direct-current plants badly located with reference to the load and containing more or less antiquated apparatus. It may be argued in favor of the operation of several power plants, as against one, that the power plants being located in different parts of the city, there is little likelihood of the same fire, flood, cyclone or other calamity destroying all of them, and thus entirely crippling the road. This, and the fact that the direct-current system is the simpler and the more easily comprehended by ordinary power plant men, are about the only arguments which may be advanced for the several power plant plan.

In a large city convenient locations for water, coal and railroad facilities are not easy to obtain near the centre of load, and it is obviously much easier to obtain one good location for a central power plant than several good locations to supply different parts of the system. A central power station should be absolutely fireproof, and if the plant is constructed on the unit system, it would be a very great calamity which would cripple more than one unit. An accident throwing out of service one unit would not be so serious as an accident incapacitating one power station, and thereby crippling the service in one part of the city. It is likely, however, that the greatest advantages of the one central plant is the fact that better supervision may be obtained, as it is much easier to get one good set of operators than several, and in times of trouble it is much easier to keep one plant in operation than several. To choose between the direct and alternating-current systems, very careful estimates of the cost of installation and operation should be made in each case, and decision should be reserved until after these estimates are compared.

In some of our largest cities, where heavy loads must be taken care of at long distances from the central station, or where the central station cannot be located near the centre of the load, or where reasons exist, such as cheap coal, water transportation, etc., for locating the central station away from the centre of load, alternating current distribution from a central station will probably be found the more economical; but if a location for an economical power plant may be obtained near the centre of load, and the total city load is comprised within a radius of 5 miles from this point, as is the case in most cities of less than 250,000 inhabitants, it is probable that direct-current generation and distribution from the central station will prove the more desirable. Where doubt exists, preference should be given to the direct-current system on account of its greater simplicity, unless there is likelihood of a great expansion of the system in the near future, when direct-current transmission might prove burdensome. In case the direct-current system is adopted, suburban lines too long or too heavy for 500-volt transmission may be supplied by alternating current generated in the power plant for their use, or by means of boosters. If the suburban lines are of moderate length or if they require normally only a small amount of power, and make unusual demands upon the power plant only at intervals, such as on holidays and pleasant Sundays, which is the condition on many suburban roads, these lines can best be taken care of by means of boosters, and the same boosting system may be useful in operating some of the city lines. A company which installs an alternating-current transmission system on its heavy city lines merely to furnish power for a few light straggling suburban lines more economically, would place itself in the illogical position of allowing the tail to wag the dog.

It is difficult to make any recommendations as to the choice between alternating and direct-current distribution in merely an abstract discussion. All that can be done is to give the arguments *pro* and *con*, with the advice that each case of generation should be figured out for itself, and no plan adopted until its advantages had been thoroughly demonstrated. The discussion in this paper has been on current generation and distribution for use in large cities.

The question of long distance transmission has not been taken up, and no attempt has been made to discuss the question of the supply of current for interurban roads, or for cities where the principal part of the load comes from interurban or long suburban roads. For these cases, alternating-current transmission unquestionably offers great advantages.

[The foregoing is an abstract of a paper presented at the twenty-second annual meeting of the American Street Railway Association at Saratoga Springs, N. Y.]

TELEPHONE ENGINEERING.

Cable Tests and Specifications.

BY F. J. DOMMERQUE.

It is the object of the present article of this series to discuss the electrical requirements which a telephone cable has to fulfil when in service, and to indicate methods of testing and making up specifications. In discussing the methods of testing, however, it is not the writer's purpose to consider in detail the instruments used nor the manner of using them; such information will be found in the catalogues of instrument makers and in the many text-books on the subject of testing.

All measurements made upon cables should be recorded, with dates and statements of weather conditions, and such measurements should be repeated from time to time so as to obtain a history of all cables in service.

Each conductor is measured for conductivity after the cable has been laid and after all splices and terminal connections are made. The measurements are made with a Wheatstone bridge (arranged for easy handling in the form of the so-called portable testing set) using a battery of four to six cells. The resistance of each conductor in a No. 16 B. & S. gauge cable should not be more than 25 ohms per mile of cable at 60° F.; in a No. 17 cable, not more than 31 ohms; in a No. 18 cable not more than 38 ohms; in a No. 19 cable not more than 47 ohms; in a No. 20 cable not more than 59 ohms, and in a No. 22 cable not more than 95 ohms.

TABLE I.—CAPACITY OF AERIAL CABLES.

No. of pairs.	B. & S. gauge.	Thickness of lead; inch meas.	Capacity per mile.	Approx. external diam. in mils.	Approx. weight per ft. in lbs.	Approx. cost per ft. f.o.b. factory in cts. (May, 1903.)
10	19	1/16	.08 to .085	815	1.0	17.8
10	20	1/16	.085 to .09	715	.8	15.2
25	19	1/12	.08 to .085	1095	1.7	27.3
25	20	1/12	.085 to .09	1015	1.3	24.5
25	22	1/12	.10 to .11	795	.9	19.3
50	19	1/10	.08 to .085	1475	3.1	39.8
50	20	1/10	.085 to .09	1355	2.3	35.4
50	22	1/10	.10 to .11	1050	1.4	29.4
75	19	7/64	.08 to .085	1750	3.8	50.8
75	20	7/64	.085 to .09	1605	3.2	45.0
75	22	7/64	.10 to .11	1235	2.0	37.0
100	22	7/64	.10 to .11	1370	2.8	45.1

The measurements for insulation resistance are usually made twice, once at the factory and the second time after the cable is in place and all terminal connections made. The factory test being more of a laboratory test, is made with a d'Arsonval or with a Thomson reflecting galvanometer, shunt, resistance box, discharge key and a 100-cell chloride of silver battery; while the final test is usually made with a d'Arsonval galvanometer. Both instruments and their use are fully described in text-books and trade literature. Any telephone company using cables should possess a galvanometer, as it is of absolute necessity to know at all times what the insulation resistance of its cables is. When the cables terminate in the basement of the exchange, the instruments are best placed upon a brick pier built in the form of a table; in other places a table may be constructed by using heavy pipes as legs and screwing flanges to the ends of the pipes, which flanges are then attached to the floor and to a substantial table platform. It is to the interest of the company to keep its instruments in perfect order and have them once in a while verified by sending them to the makers or some reliable laboratory for testing and comparing to standard instruments. The test for insulation is made by measuring each wire in the cable against all the others, those being all connected together and also to the lead sheath, which latter is then grounded; in order to get a correct reading one minute's "electrification" should be allowed.

Of course, when the cable is tested at the factory the insulation resistance should be high, various specifications demanding a resistance of from 500 to 5000 megohms, while the insulation resistance specified for the cable in place and connected to terminals varies from 100 to 1000 megohms per mile at 60° F. It is not unreasonable to specify that when tested at the factory the cable should test not less than 4000 megohms per mile. When in place, it depends on the terminals used. Some engineers demand that the terminals shall test as high as the cables, which, however, is a very difficult condition to obtain; the office terminal as a rule is very good with respect to insulation resistance, but the outside terminal, in a cable box on a pole or in a basement, often requires great expense to make it test high. For practical purposes an outside terminal showing 10 to 50 megohms insulation resistance will answer the purpose. Therefore, when the insulation resistance for cables in place is specified, it should be mentioned whether the measurements are to be made with outside terminals or not. If without, the insulation resistance should not be less than 500 megohms per mile, including office terminals and all splices. If the cable is bought and placed by a contractor, it would be necessary to specify also the kind of outside terminals to be used or the insulation resistance, including such terminals. In such a case, 300 megohms insulation resistance per mile should be the minimum.

TABLE II.—CAPACITY OF UNDERGROUND CABLES.

No. of pairs.	B. & S. gauge.	Thickness of lead; inch meas.	Capacity per mile.	Approx. external diam. in mils.	Approx. weight per ft. in lbs.	Approx. cost per ft. f.o.b. factory in cts. (May, 1903.)
25	19	3/32	.08 to .085	1120	1.9	27.3
25	20	3/32	.085 to .09	1060	1.6	24.5
25	22	3/32	.10 to .11	820	1.0	19.3
50	19	7/64	.08 to .085	1495	3.4	39.8
50	20	7/64	.085 to .09	1375	2.7	35.4
50	22	7/64	.10 to .11	1070	1.7	29.4
100	19	1/8	.08 to .085	2003	4.9	65.1
100	20	1/8	.085 to .09	1815	4.2	57.0
100	22	1/8	.10 to .11	1400	3.0	47.5
150	19	1/8	.08 to .085	2380	6.2	86.3
150	20	1/8	.085 to .09	2160	5.3	75.4
150	22	1/8	.10 to .11	1650	4.0	62.2
200	19	1/8	.10 to .11	2309	6.7	101.0
200	20	1/8	.10 to .11	2177	5.5	89.4
200	22	1/8	.11 to .12	1800	4.6	75.2
250	22	1/8	.11 to .12	1975	5.2	87.8
300	22	1/8	.11 to .12	2140	5.7	99.3
350	22	1/8	.11 to .12	2280	6.4	114.0
400	22	1/8	.11 to .12	2420	6.9	126.5

As mentioned before, the electrostatic capacity of a cable depends upon the distance between conductors. Naturally, it is desirable to have a very small capacity, but we are limited in that respect as the cable must not exceed a certain diameter, so that it may be easily suspended from poles or drawn into conduits. The capacity test is also made with a galvanometer, shunt and discharge key, but in this case a standard condenser takes the place of the resistance. Six cells of battery are sufficient for very long cables, while shorter cables require much more. This test is also made by measuring each wire in the cable against all the others connected together and to the lead sheath grounded. Of course, the longer the line, the smaller the capacity per mile should be, and practice has fixed the maximum limits. As capacity is so involved with the other cable measurements, tables showing the approximate weight and external diameter of the cable are given so as to permit the purchaser to form an idea of the relation of capacity to size and weight of cable. All measurements apply at a temperature of 60° F. The tables give the capacity per mile of cable in microfarads in conjunction with the external diameter, thickness of sheath and weight per foot.

As the cost of manufacturing cables is very small in comparison to the cost of raw material used, the cost of finished cables is a variable quantity and practically is dictated by the copper and lead market. For this reason we find that cable quotations of manufacturers contain nearly always a clause stating that the quotations hold good for a specified time only. In order, however, to enable the telephone man to form an idea of the relative value of cable, some approximate figures of prices on board cars at factory are given; these for the sake of brevity being added in the last column of the capacity tables. These prices are for plain lead sheaths; where an admixture of tin (average of 3 per cent) is required, the following additions should be made: 1½ cents per foot of 25 pair; 2 cents per foot of 50 pair: 2½ cents per foot of 75 pair; 3 cents per foot of 100 pair; 3½ cents per foot of 150 pair; 4 cents per foot of 200 pair; 4½ cents per foot of 250 pair; 5 cents per foot of 300 pair; 5½ cents per foot of 350 pair, and 6 cents per foot of 400 pair.

When in need of cables, it is absolutely necessary to ask for quotations from the manufacturer in every case. When doing so it is the custom to submit a specification the manufacturer should be guided by and to which he is expected to be held. Such specifications very often contain demands that could not be fulfilled conscientiously by the manufacturer without making his product come so high that he could not compete with a less conscientious manufacturer, who would put in a bid for the cable at a lower price, neglecting such demands in the specification, as he expects the purchaser will not be able to verify. It therefore seems the best method in asking for bids on cables to make the specifications short but precise, stating the principal requirements and trusting to some extent in the reputation of the manufacturer for turning out good cable and coming up to specifications as a means to maintain his reputation as well as to secure more orders in the future, rather than to draw up specifications that require a lawyer to interpret.

Many purchasers wish the cable manufacturer to install the cables. In such cases the specifications should differ from the ones used only in buying cables and should specify methods of construction in general, but principally the results to be obtained. At this juncture we are only interested in the specifications for ordering cables; the writer, therefore, leaves it for a later occasion to specify the requirements for the installation of cable.

There should in reality never be occasion for a telephone company to call upon a third party or the cable manufacturer to install its cables, as it seems like letting good money slip away when a man pays for work being done by somebody else that can be done by himself or his help; and there is very little capital required for tools for doing it. However, there remains the question as to where the line of responsibility should be drawn. If a third party installs the cable and makes splices, etc., can we make the manufacturer responsible for the defects in the cable if such should appear when the cable is in place? On the other hand, how can we find out after a number of years whether the cable has retained its guaranteed qualities, or rather how are we to prove that it is the manufacturer's fault if the cable shows defects after a certain time?

GENTLEMEN:—

Under the conditions hereinafter specified please deliver the following enumerated telephone cables free on board cars at freight depot in......................
..............reel, marked..........., containing............feet of No.....B. & S.
gauge, ...pair, aerial (or underground) paper cable, capacity........to........
m.f. per mile, ...inch plain lead (or with.......per cent tin) at quoted price
of........cents per foot.
..............reel. marked..............., containing, etc., etc.

Conductors.—Each conductor shall fully and throughout its entire length have the diameter corresponding to the gauge stated above and shall be cylindrical and free from imperfections. The material of the conductors shall be soft-drawn copper.

Insulation.—Each conductor shall be insulated with one (or two reversed) wrapping of dry paper; the insulation of one conductor in each pair shall be colored blue and that of the other conductor red.

Number of Pairs.—Each cable shall have the number of pairs called for above, plus at least one extra or additional pair for each one hundred (100) or fractional part of one hundred (100) pairs of conductors called for.

Twisting.—The two wires of each pair shall be twisted together with a uniform lay not to exceed approximately three inches for No. 19 B. & S. gauge and smaller wires and approximately six inches for larger wires in a complete twist, so as to effectively prevent cross-talk.

Cabling.—The twisted pairs shall be laid up into a cylindrical core, arranged in reversed layers, so that the length of each complete turn shall not exceed thirty inches.

Sheath.—The core shall be encased in a cylindrical sheath of plain lead (or an alloy of lead and......per cent tin) of the thickness specified above. The sheath shall be free from holes or other imperfections and shall be of uniform thickness and composition.

Conductor Resistance.—Each conductor shall have a resistance equivalent to not more than...25...ohms per mile of No. 16 B. & S. gauge cable; not more than ...31...ohms per mile of No. 17 B. & S. gauge cable; not more than...38...ohms per mile of No. 18 B. & S. gauge cable; not more than...47...ohms per mile of No. 19 B. & S. gauge cable; not more than...59...ohms per mile of No. 20 B. & S. gauge cable; not more than...95...ohms per mile of No. 22 B. & S. gauge cable.

All measurements to be made at 60° F.

The conductivity of any wire shall be equal to at least 98 per cent of pure copper.

Insulation Resistance.—Each wire shall have an insulation resistance of not less than three thousand (3000) megohms per mile at 60° F., when tested at the factory in the usual manner, and shall have an insulation resistance of not less than five hundred (500) megohms per mile at 60° F., when installed, spliced and connected to office terminals; each wire being measured against all the rest and the sheath grounded.

Electrostatic Capacity.—The electrostatic capacity of the wires shall remain inside the limits specified above. These limits to apply to measurements of each wire against all the rest and the sheath grounded and at a temperature of 60° F.

Packing and Shipping.—The cable shall be delivered on reels in lengths specified above. At least eighteen inches of the inside end of the cable shall be brought out through the side of the reel so as to be accessible for testing. This end shall be securely boxed to protect it from mechanical injury. The outside layer of cable on each reel shall be properly wrapped, and each reel shall be incased in stout lagging. Each reel to carry in plain sight the company's name, the above specified identification mark, length and size of the cable.

Delivery.—Reel marked........, shall be delivered at.......................... on or shortly before.....................190.. Reed marked........at.......... on or shortly before..............etc., etc.

Measurements and Tests.—The company reserves the right to send an inspector to the factory to be present during the process of manufacturing and to test the qualities of the materials used and the electrical properties of the cable before shipping. He shall have the power to reject any material or cable found defective. Such inspection, however, shall not relieve the manufacturer from furnishing perfect material and satisfactory work. Final measurements and tests are to be made after the cable is installed, spliced and connected to office terminals. In case the cable falls so far short of the above specified requirements that the company is not willing to accept it, the manufacturer will be called upon to examine the work done by the company, and if able, by re-making splices or repairing injuries to the cable received in handling and laying, to bring the cable up to the requirements. The cost of the work shall be borne by the company. If such work, however, does not bring the cable up to the requirements, and the cable is shown to be defective in material or work done by the manufacturer, then the manufacturer shall make the cable good by replacing as many lengths as may be necessary, and shall not be entitled to pay for work done in examining and remaking splices. The company will, if the manufacturer fails to do so, perform all the work of testing and remaking splices, and charge the cost of such work to the manufacturer in case the defect is found to be due to poor material or workmanship on the part of the manufacturer. The manufacturer shall be notified as soon as the company's inspector reports any defects, and he may have a representative present during such tests and work done by the company to detect or repair defects. The company reserves the right to have a representative present whenever the cable is tested or work is done by the manufacturer in repairing defects.

Guarantee.—The electrostatic capacity shall not increase, nor shall the insulation resistance decrease, beyond the specified limits due to defective material, manufacture or workmanship, for a period of..........years after the cable has been installed.

Payments.—Payments for the cable shall be made within thirty (30) days from the receipt of a consignment, except that fifteen (15) per cent of the price of each consignment shall be held thirty (30) days after each separate consignment is installed and accepted by the inspector of this company, who shall make a written report accepting or rejecting the cable within twenty days after installation; in case of rejection a written notice and statement of the defects shall be sent immediately to the manufacturer and if the manufacturer fails inside of ten days to remedy such defects, they will be remedied by the company and the cost deducted from the final payments, or if the percentage is not sufficient to pay for such repairs, the manufacturer must refund the difference.

(Signed)

....Telephone Company.

In the accompanying sample order and specification for cables, the writer has tried to be just and fair to the manufacturer and protect the purchaser at the same time. It is assumed that the purchaser has asked for quotations by making a short statement of his requirements containing the measurements, sizes, capacities, thickness of lead (when making measurements for cable orders, allowance must be made for splices, slack, terminal ends; the requirements for which will be taken up later) and the other essential data required by the manufacturer to make an intelligent bid; and after he has selected from the various propositions the one that seems the best for his interest, he can either make a formal contract or give the order in the accompanying letter form.

So far the writer has devoted the discussion almost exclusively to cable of No. 19, 20 and 22 gauge wire. Such cable is used for all subscribers' lines, and it may be used to good advantage also for trunk lines; however, it requires careful study to determine what gauge should be chosen for the trunk lines.

In existing plants where no 22-gauge is employed for subscribers' lines, such cable may find a good place for trunk lines, but if 22-gauge cable is already in use for subscribers' lines, either wholly or in part, it will depend upon the distance between offices what gauge cable should be chosen for the trunk lines. The tendency in new plants is to use, almost exclusively, underground and aerial cable for subscribers' lines, leaving only the distribution to the premises to open wires, and to employ 22-gauge cable throughout; with this practice there will be little chance for 22-gauge trunk line cables, certainly when in connection therewith the toll and long-distance business is taken in consideration. In such cases a No. 19 or even larger gauge cable will be better for trunks; but if the number of trunks is great enough to require more than one cable, a small gauge cable may serve to send the local business over, while one of a larger gauge may act as a relief cable for toll and long-distance business.

With 19-gauge cable for subscribers' lines and 22-gauge cables for trunk lines, sending toll and long-distance business over relief cables, the distance between two offices may be as much as fifteen miles. It is, of course, assumed always that in cities large enough to require trunking, a common battery is used for talking and possibly, but not necessarily, very high resistance transmitters with a high-voltage battery.

For toll and long-distance lines pure and simple a No. 16 gauge cable may be used, if there are enough lines to allow the use of a cable, and when the lines cannot be brought to the exchange in open wires. The capacity of such a cable should not exceed 0.065 microfarads per mile, which would limit the number of pairs in such a cable to 50, as a 50-pair No. 16 B. & S. gauge cable of 0.065 microfarads capacity, and with a 9/64-in. lead sheath has a diameter of 2⅝ inches, which is about the limit for drawing into ducts. As stated repeatedly, the tendency is toward finer gauge conductors for cables.

Electrical Equipment of an Industrial Plant

POWER AND LIGHTING PLANT OF THE GRAND UNION TEA COMPANY AT BROOKLYN, N. Y.

The installation of electrical machinery for purposes of power and light has reached the point where, instead of being considered as a possibility, it is now the first and only means considered where large amounts of power are used in varying classes of work. The interesting installation just completed at the tea, coffee, spice and soap plant of Jones Brothers (better known as the Grand Union Tea Company), Pearl, Front and Water Streets, Brooklyn, illustrates the advantages of individual and group driving, and also the possibilities of installing a large plant and of changing over without losing a minute's time. The aim throughout the entire work has been to construct a plant, modern in all details, and so arranged as to make a shut-down almost an impossibility. Each of the three buildings which compose the plant is six stories high and of modern fire-proof construction, the total floor space in use being 168,000 square feet. All the machinery connected with the various departments is driven by electric motors, the power being supplied from a steam and electric plant of about 1,000 horse-power ultimate capacity, situated in the basement and first floor of the Water Street building.

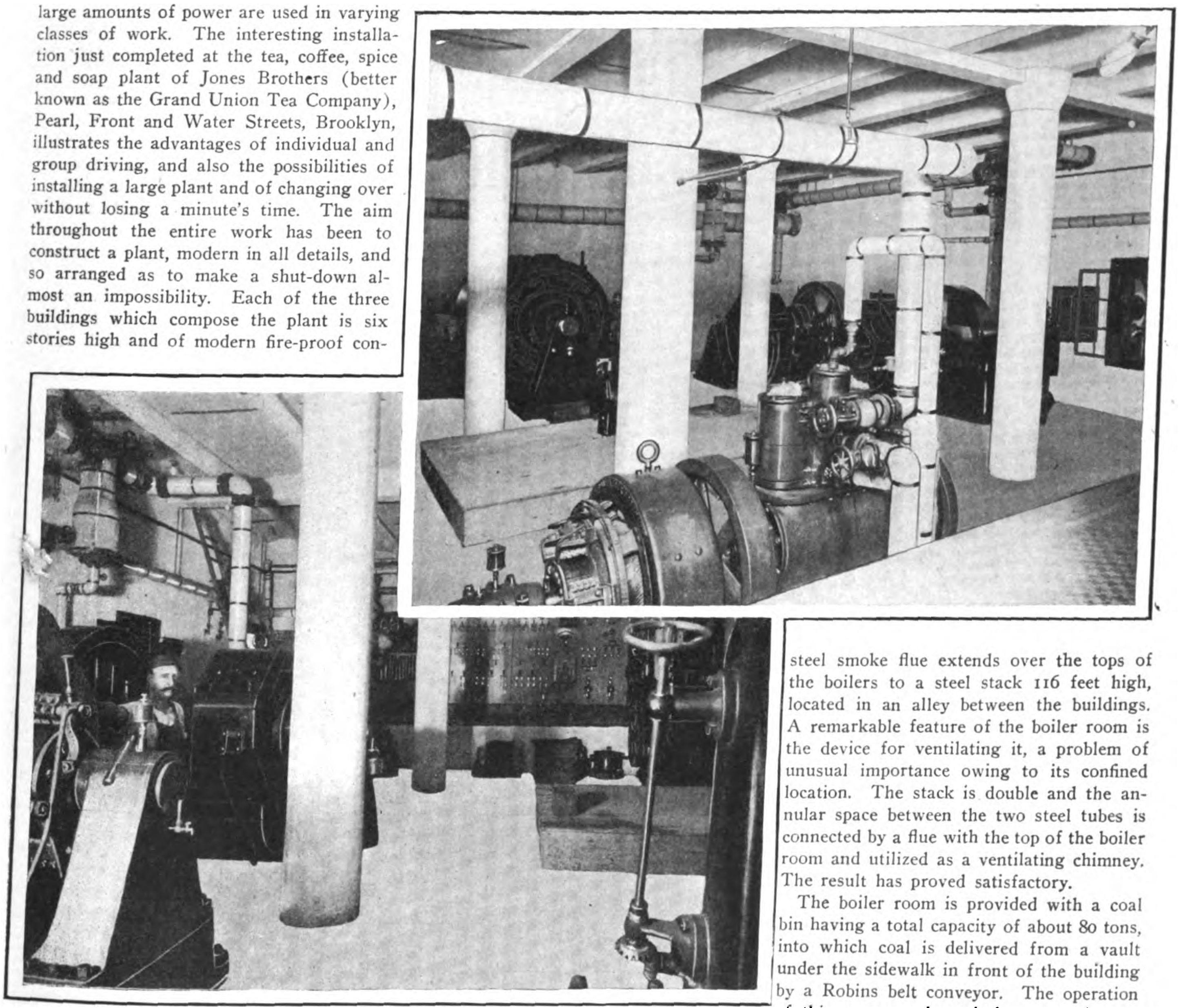

FIG. I.—TWO VIEWS OF GRAND UNION TEA COMPANY'S ENGINE ROOM.

The power plant as at present completed consists of four direct-connected units, as follows: One 325-h.p. Ames engine, coupled to a 200-kw. Westinghouse generator; two 125-h.p. Ames engines, coupled to 75-kw. Eddy generators, and one 60-h.p. Westinghouse engine, coupled to a 37-kw. Keystone generator. Space has been provided for an additional 200-kw. unit which will shortly be installed. The engines and generators are set upon massive brick foundations, raising them to within four feet of the street level, the space between and surrounding the foundations being utilized for the exhaust piping, electric wiring distribution, drainage and oil systems, and feed-water pumps, heaters and traps. The plant was designed so that these spaces are well ventilated and brilliantly lighted, and of ample size to work in without stooping; all of the appliances enumerated are so placed as to be easily accessible for attention and repairs.

The boiler room is situated in the basement at the rear of the building and extends through the first floor. It contains three Aultman & Taylor horizontal water-tube boilers with a total capacity of 900 horse-power when operated under a steam pressure of 150 pounds. These boilers are provided with Imperial shaking grates, designed to burn anthracite pea coal. The steel smoke flue extends over the tops of the boilers to a steel stack 116 feet high, located in an alley between the buildings. A remarkable feature of the boiler room is the device for ventilating it, a problem of unusual importance owing to its confined location. The stack is double and the annular space between the two steel tubes is connected by a flue with the top of the boiler room and utilized as a ventilating chimney. The result has proved satisfactory.

The boiler room is provided with a coal bin having a total capacity of about 80 tons, into which coal is delivered from a vault under the sidewalk in front of the building by a Robins belt conveyor. The operation of this conveyor is entirely automatic, the coal being delivered from the carts into a chute supplying the belt, which in turn carries it to the boiler room and by means of a tripper distributes it evenly throughout the entire length of the bin. Provision is also made for a further storage capacity of 70 tons in the vault under the sidewalk. Feed-water is supplied through a duplicate set of Fairbanks-Morse duplex boiler feed pumps, shown by Fig. 4. For the high-pressure steam work, extra heavy pipe with gun metal fittings is provided, and the plant is equipped throughout with Scott gate valves and Oakes "Acorn" globe valves. Fig. 3 shows a plan view of the engine and boiler rooms, with the steam connections, and Fig. 2 is a diagram of the small piping for the steam plant. The general lay-out of the plant is so clearly shown in these engravings that further comment is unnecessary.

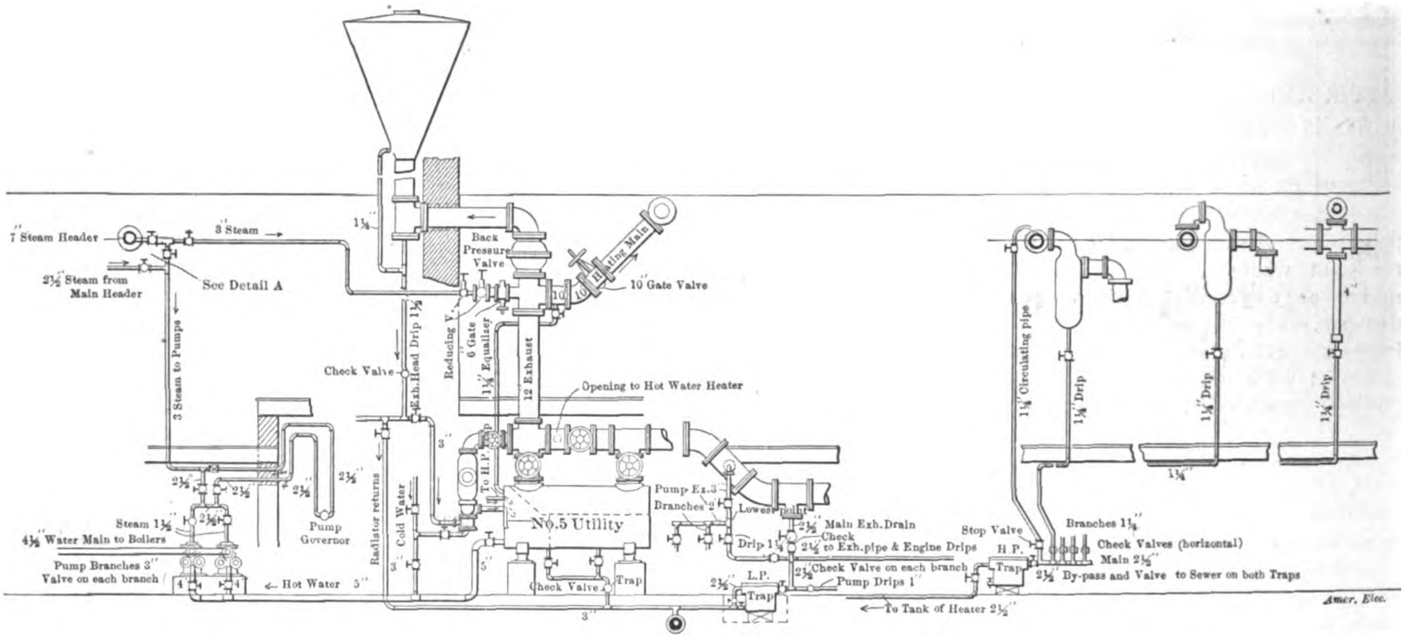
7" Steam Header
3" Steam
2½" Steam from Main Header
See Detail A
1¼"
Back Pressure Valve
Heating Main
10" Gate Valve
10
10
Reducing V.
6" Gate
1¼" Equalizer
12 Exhaust
Exh. Head Drip 1½
Check Valve
3 Steam to Pumps
Opening to Hot Water Heater
3"
To H.P. Trap
2½"
2½
2½
2½"
Steam 1½"
4½" Water Main to Boilers
Pump Branches 3" Valve on each branch
4
4
Hot Water 5"
Pump Governor
Radiator returns
Cold Water
3"
5"
No. 5 Utility
Check Valve
Trap
3"
Pump Ex. 3"
Branches 2"
Lowest point
Drip 1¼
2½" Main Exh. Drain
Check
2½ to Exh. pipe & Engine Drips
2½" Check Valve on each branch
Pump Drips 1"
2½"
L.P.
Trap
To Tank of Heater 2½"
1¼" Circulating pipe
1¼" Drip
1¼" Drip
1¼" Drip
4"
1¼"
Stop Valve
H.P.
Trap
Branches 1¼"
Check Valves (horizontal)
Main 2½"
2½" By-pass and Valve to Sewer on both Traps
Amer. Elec.

FIG. 2.—DIAGRAM OF SMALL PIPING FOR STEAM PLANT.

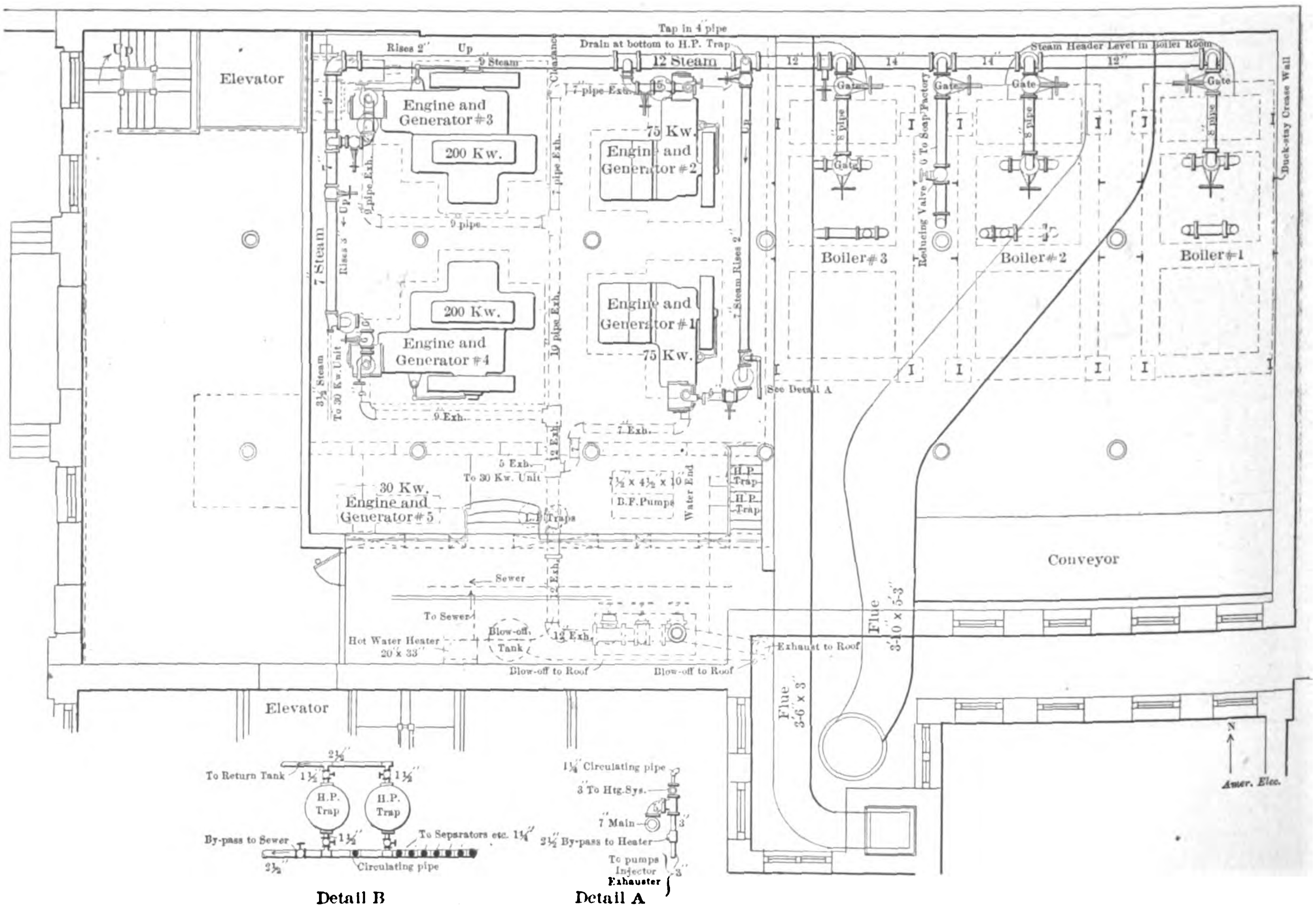
Up
Elevator
Rises 2"
Up
9" Steam
Tap in 4" pipe
Drain at bottom to H.P. Trap
12 Steam
Steam Header Level in Boiler Room
12"
14"
14"
12"
Duck-stay Cross Wall
Engine and Generator #3
200 Kw.
9" pipe Exh.
Clearance
7" pipe Exh.
75 Kw.
Engine and Generator #2
Gate
Gate
Gate
Gate
8" pipe
To Soap Factory
8" pipe
8" pipe
Reducing Valve
Boiler #3
Boiler #2
Boiler #1
9" pipe
7" Steam
Rises 3"
200 Kw.
Engine and Generator #4
10" pipe Exh.
Engine and Generator #1
75 Kw.
7" Steam Rises 2"
See Detail A
3½" Steam To 30 Kw. Unit
9" Exh.
7" Exh.
12 Exh.
5" Exh. To 30 Kw. Unit
30 Kw. Engine and Generator #5
L.P. Traps
7½" x 4½" x 10" B.F. Pumps
Water End
H.P. Trap
H.P. Trap
Conveyor
Sewer
To Sewer
Hot Water Heater 20" x 33"
Blow-off Tank
12" Exh.
Blow-off to Roof
Blow-off to Roof
Exhaust to Roof
Flue 3'-0" x 5'-3"
Flue 3'-6" x 3'
Elevator
N
Amer. Elec.
2½"
To Return Tank
1½"
1½"
H.P. Trap
H.P. Trap
By-pass to Sewer
1½"
To Separators etc. 1¼"
2½"
Circulating pipe
1¼" Circulating pipe
3" To Htg. Sys.
7" Main
3"
2½" By-pass to Heater
To pumps Injector Exhauster
3"
Detail B
Detail A

FIG. 3.—PLAN VIEW OF ENGINE AND BOILER ROOMS SHOWING STEAM CONNECTIONS.

Fig. 1 shows two views of the engine room, from which the lay-out of the various units may be clearly seen. The 200-kw. unit carries its full load throughout the day, but one of the 75-kw. machines is kept turning over at all times as a precautionary measure. Part of the work of this plant consists in driving coffee-roasting apparatus, and a shut-down of even a minute would spoil from $500 to $1,000 worth of coffee. It is, therefore, easily seen that it was necessary to have auxiliary machinery which could be run without too great a steam consumption. One of the main points of this engine room is the fact that it is on the ground floor, making it airy and light, so that the machinery can be given the best possible attention. From the switchboard platform, on which is located the engineer's office, a free view is had of all the machinery, also of all steam and other gauges, so that the engineer has at all times full command and is in sight of his apparatus. Although seven elevators are in constant operation, there is never a

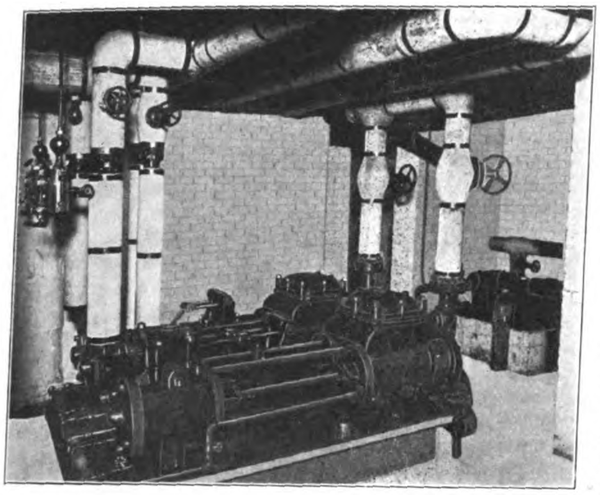

FIG. 4.—DUPLICATE FEED PUMPS.

variation of more than 2 per cent in the voltage on the driving machines; this is due to the heavy fly-wheel with which all of the engines are equipped. The 37-kw. unit is used for lighting the plant at night or for running in conjunction with one of the larger machines when necessary.

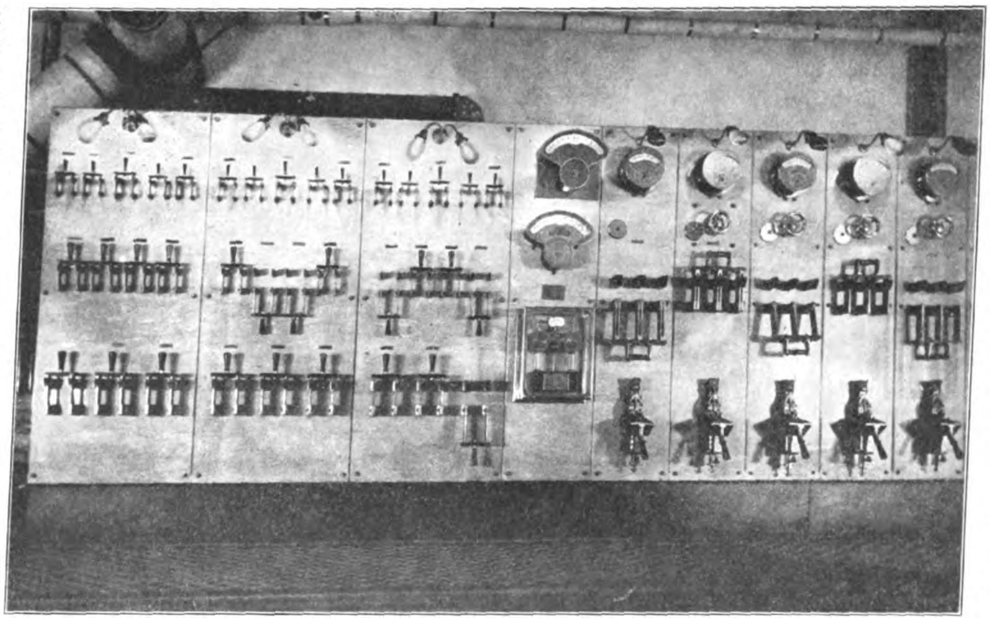

FIG. 5.—VIEW OF MAIN SWITCHBOARD.

The switchboard shown by Fig. 5 is situated upon an elevated platform in the engine room and is 17 feet long and 6½ feet high. It was built by the Walker Electric Company, of Philadelphia and consists of ten panels. These are made of Tennessee marble and are divided as follows: One main output panel, five generator panels, one storage battery panel, three feeder panels. On the main output panel there are mounted the main voltmeter hung on brackets, the main ammeter and a Thomson recording wattmeter. Each of the generator panels has an ammeter of suitable size, a rheostat, a triple-pole main switch and a novel form of voltmeter switch. The storage battery panel is equipped with an ammeter, a booster rheostat, a starting box, a voltmeter switch and the usual storage battery operating switches. The feeder panels control the entire output of the plant, both for lighting and power, and are provided with 36 switches controlling 36 separate distributing circuits varying in capacity from 50 amperes to 400 amperes. The voltmeter switch, provided on the five generator panels and the storage panel, is a simple push-button, which is held out of engagement by a spring. These buttons serve to operate switches on the back of the board, which are so connected to the auxiliary voltmeter circuit, which normally registers bus-bar voltage, that when the button on any particular panel is pressed the voltmeter is at once placed across the terminals of the machine which that panel controls; when the button is released the voltmeter again registers the bus-bar voltage. With this device, the necessity for a portable voltmeter disappears; irrespective of the length of the board or the distance between any generator panel and the stationary voltmeter, each machine may be built up and cut in on the board by the operator without moving from his place in front of the panel of the generator on which he is working.

On each of the floors of the three buildings is placed a pair of panel boards, one of which controls the power circuits for that floor, and the other the lighting circuits. Throughout each of the buildings the panel boards on the various floors for lighting or for power are identical and are provided with switches of assorted sizes suitable to control any load which may be required on any floor. For instance, in the building on the corner of Front and Pearl Streets, the panel boards for power have each one circuit of 125 amperes, two circuits of 60 amperes, and two circuits of 30 amperes, and the panel boards for lighting have each twelve circuits of 15 amperes. This arrangement provides great facilities for quick repair in case of accident, for there is almost certain to be a spare switch of each size somewhere in the building which can be removed and substituted quickly in case of a break-down on one of the boards. All panel boards are provided with enclosed non-arcing fuses and are connected directly to the main switchboard by leads varying from 400,000 circular mils down, according to the needs of each particular floor, all being run in metal conduit enclosed in the walls and floors of the buildings.

There are two coffee-roasting rooms, one containing 23 cylinders and the other 8 cylinders. They are each situated on the upper floor of the building for convenience of ventilation and disposal of refuse. The roasted coffee descends from these rooms by gravity to the lower floors, where it is placed in bags for shipment. Figs. 7 and 8 show the coffee-roasting rooms. For driving the roasting plant there are three motors, two of 30 horse-power capacity and one of 15 horse-power capacity. The two 30-h.p. motors are belted to an overhead countershaft and drive the 23 cylinders; the 15-h.p. motor is geared direct to the 8-cylinder plant. The cooler, stoner and chaff fans connected with the larger plant are driven by belt from the countershaft referred to, while the corresponding fans in the smaller and more modern plant are driven by three direct-connected motors, two of which are of 7½ horse-power capacity and the other of one horse-power capacity. The roasters and their auxiliary machinery were furnished by Messrs. Jabez Burns & Sons, and are models of completeness.

On the floor below the roasting plant is the green coffee and finishing department. Here are located in one room a green coffee mixer, six screeners, three stoners, three water polishers, three peaberry separators, three milling machines, three dust collectors, three shakers, one coffee mill, and a conveyor to carry the cof-

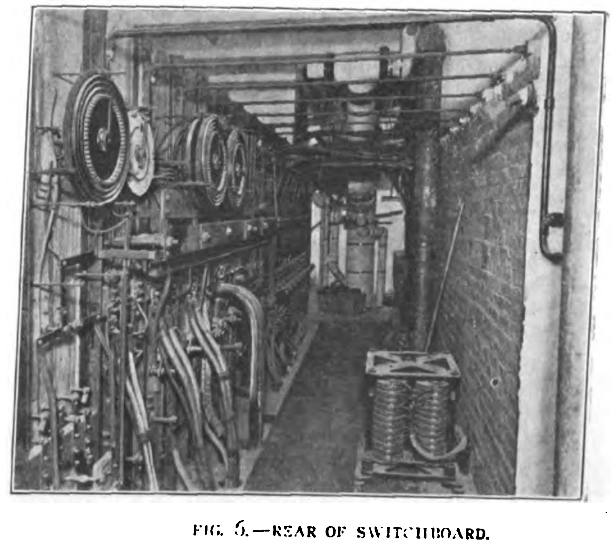

FIG. 6.—REAR OF SWITCHBOARD.

fee back and forth. These are driven by one 40-h.p. motor, five 7½-h.p. motors, one 5-h.p. motor, and three ½-h.p. motors. The motors are conveniently placed in the corners of the room and on overhead brackets; the machines are all belt-driven. The other finishing room has one green coffee mixer, a water polisher, a milling machine, a shaker, a berry separator, and a stoner, which are driven in a similar manner by one 30-h.p. motor, one 7½-h.p. motor and one ½-h.p. motor. A view of this room is given by Fig. 12. On this floor is also located the bag department with its bag machinery and printing outfit, driven by two 5-h.p. motors, as shown in Fig. 9.

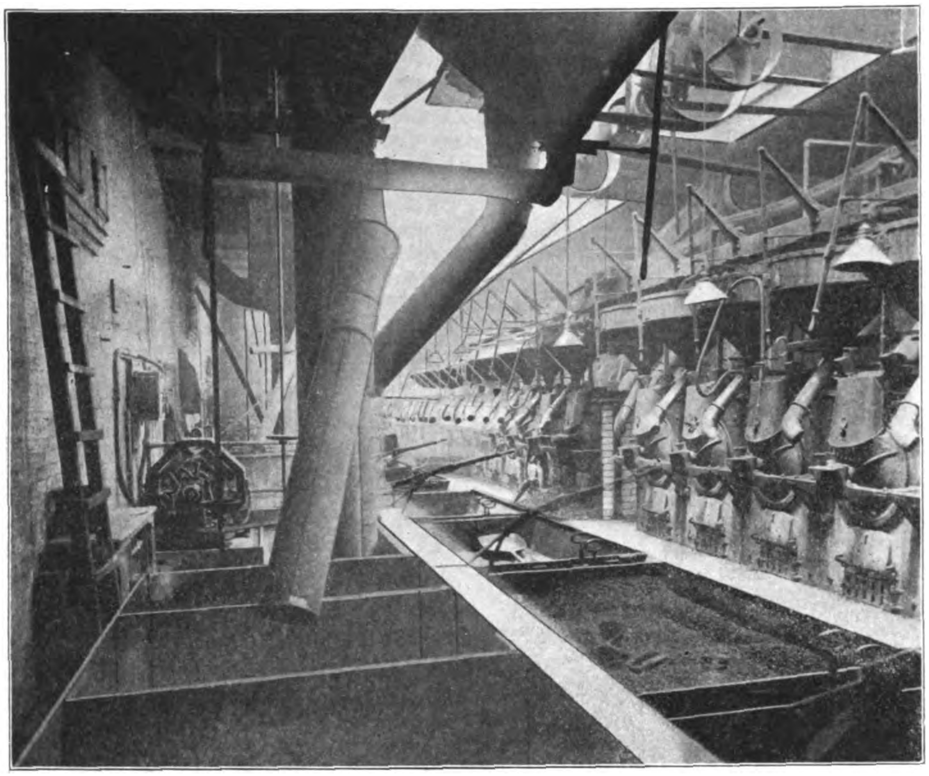

FIG. 7.—VIEW OF LARGE COFFEE ROASTING ROOM.

The spice department is on the third floor and is contained in two rooms, one of which contains two Challenge mills, one mixer, one spice cracker and one grindstone, all driven by a 15-h.p. motor. The other spice room contains one screener, two Challenge mills, and one Cogswell mill with its feeder and elevator, the whole being driven by one 30-h.p. motor and one 20-h.p. motor. The mustard room, located nearby, contains one spice cracker, one mustard pounder and two mustard screeners, all driven by a 10-h.p. slow-speed motor. The extract department is driven by a 2-h.p. motor and contains two steam kettles, one seed grinder and one mixer. The baking powder department contains two baking powder machines driven by a 5-h.p. motor, and one automatic weighing machine driven by a 3-h.p. motor. The tea blending department contains a rotating mixer driven by a 1½-h.p. slow-speed motor. The tin shop, a view of which is given by Fig. 10, is located on the sixth floor of one of the buildings, and contains all the requisite machinery for making the packages of various kinds used by the firm. It contains one double seamer, three grooving machines, three burring machines, two button presses, one splitter and one edging machine, all of which are driven by a 5-h.p. motor.

The printing department is located on the first floor, near the corner of Front and Pearl Streets, and is equipped with a No. 9 Cottrell perfecting press, a Whitlock press, a Whitlock pony press, a Colt's armory press, two Gordon presses, a Golden press, a folding machine, a Brown & Carver cutter, and a Cottrell rewinder. The perfecting press is driven by a 7½-h.p. motor belted directly to it and provided with a Carpenter controller permitting of a large number of different speeds both forward and back. The Brown & Carver cutter has also a motor of its own geared directly to it. The remainder of the plant is driven by a 15-h.p. motor placed in one corner and belted to a line of shafting extending across the room, from which belts are taken to the various machines and presses.

The soap factory occupies all of the new building on Water Street above the power plant. On the fifth floor of this building are placed nine huge soap kettles, seven of which have a capacity of 100,000 pounds of soap each, the other two being of 35,000 pounds capacity and used for special soaps. These kettles extend up through the floor of the sixth story, which is the operating room of the factory from which the kettles are filled and all the various operations of soap making are carried on. Here are also located the steaming room for melting the greases and oils, the lye-melting tank, and a Jobbins glycerine tank for treating the waste lyes for the recovery of the glycerine and salt. The only power required on this floor is for the motor-driven vacuum pump shown by Fig. 15, which forms part of the glycerine plant, and this is equipped with a 7½-h.p. motor running at 750 r.p.m. and driving the pump through the medium of a Renold silent chain.

On the fifth floor are located the pumps and crutchers for handling the partly made soap, and the grease, oil and soap tanks, seven in number. There are also on this floor two No. 6 Lobee pumps, two 48-in. horizontal crutchers and one upright mixer. The pumps and mixer are driven by a 24-h.p. motor running at 880 r.p.m., and the crutchers by a 20-h.p. motor running at 800 r.p.m., the motors in each case being belted to an overhead countershaft and from there to the machines. Means are provided for running the crutchers in the reverse direction if required, as when making white soap.

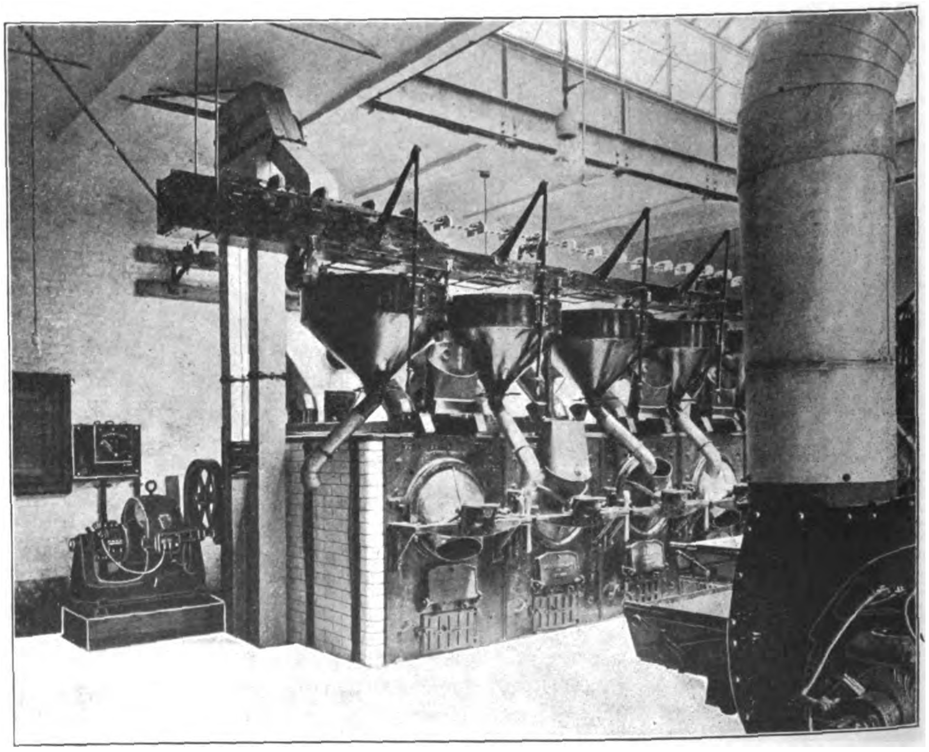

FIG. 8.—VIEW OF SMALLER AND MORE MODERN COFFEE ROASTING ROOM.

The piping system is very elaborate and connects all of the tanks and kettles, so that the contents of any one receptacle may be pumped to any other point of the plant at the will of the operator. The circulating grease and oil distributing pumps are equipped with Fairbanks asbestos cocks. A view of this room is given by Fig. 16.

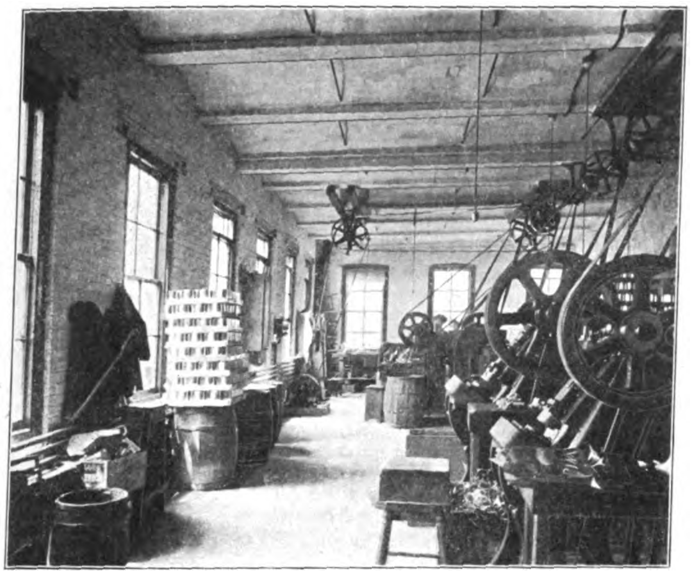

FIG. 9.—VIEW OF TIN SHOP.

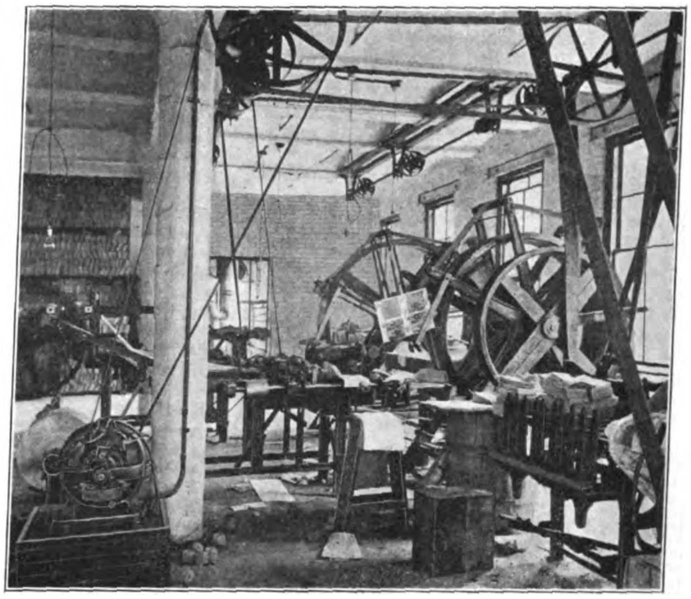

FIG. 10.—PAPER BAG DEPARTMENT.

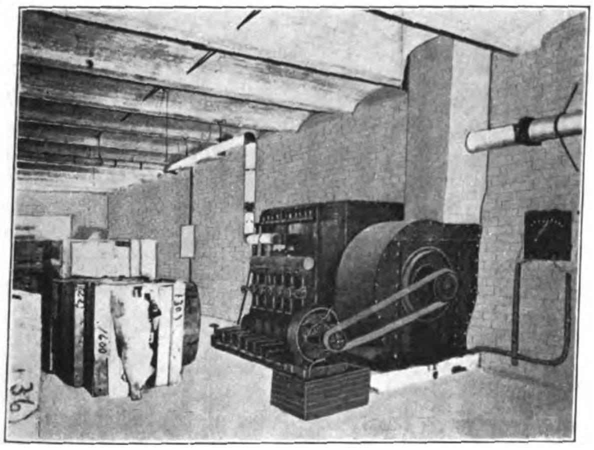

FIG. 11.—DRYING EQUIPMENT IN SOAP FACTORY.

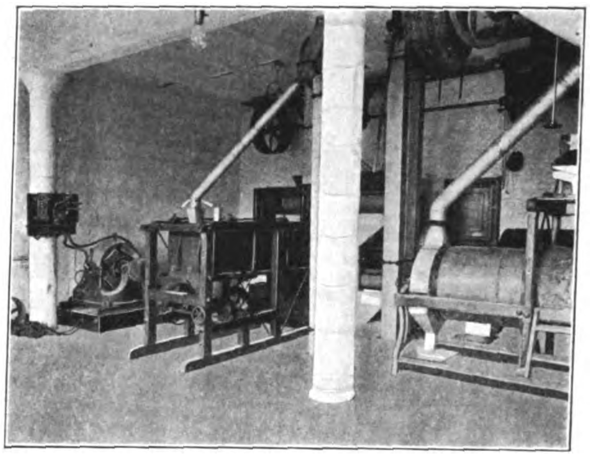

FIG. 12.—COFFEE FINISHING ROOM.

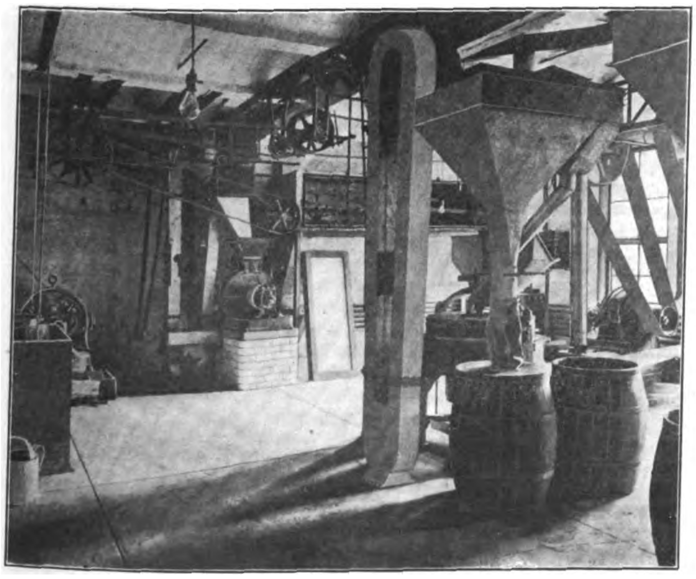

FIG. 13.—CORNER OF SPICE ROOM.

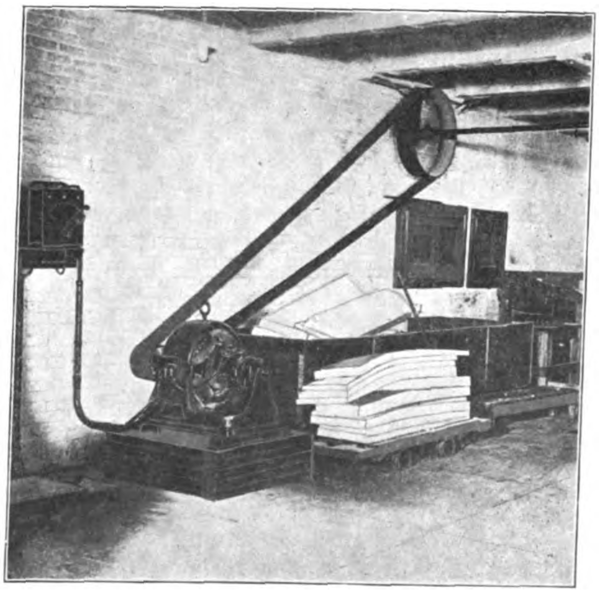

FIG. 14.—CORNER OF SLABBER AND CUTTING ROOM IN SOAP FACTORY.

On the fourth floor are the waste lye tanks and the soap powder mill, the remaining space being utilized for filling the frames from the crutchers on the floor above and storing and cooling the same. The crusher and powder mill were furnished by the Blanchard Machine Company and are driven by a 10-h.p. motor running at 835 r.p.m. The output of this machine is carried by a chute to the floor below, where the powder is weighed and put in boxes for shipment. The third floor is devoted to the cutting, drying and pressing of the finished soap, which is also here wrapped and boxed for shipment. The dry room situated in the rear of this loft is heated and ventilated by a 60-in. Buffalo fan and heater placed in the room below and connected with the dry room by galvanized iron flues. The fan is driven by a 6-h.p. motor, running at 865 r.p.m., and connected to it as shown in Fig. 11 by a Renold chain. The heater is in six sections, any of which may be turned on or off at pleasure, thus providing a great flexibility in the control of the temperature of the room. The slabber and cutting tables occupy one side of the space in front of the dry room, and the press and packing table the other, the former being driven by a 10-h.p. slow-speed motor, and the latter by a 5-h.p. motor of similar design. The remaining space of the building is utilized for offices and storage. There are two electric freight elevators connecting all the floors for carrying the various materials up and down. The capacity of the soap plant running single time is 500 boxes of soap per day, and this can be doubled by working two shifts. There are 34 motors in use, varying in size from ½ horse-power to 50 horse-power; most of these were furnished by the Keystone Electric Company, Erie, Pa.; other makes of motors in use include the Eddy, Lundell, Watson, Sturtevant and C. & C.

Messrs. H. B. Coho & Co., of New York City, were the engineers and contractors for the entire equipment, including the power plant and all its accessories. We are indebted to them and to the engineer of the plant, Mr. J. Calvin, for many courtesies extended in the preparation of this article.

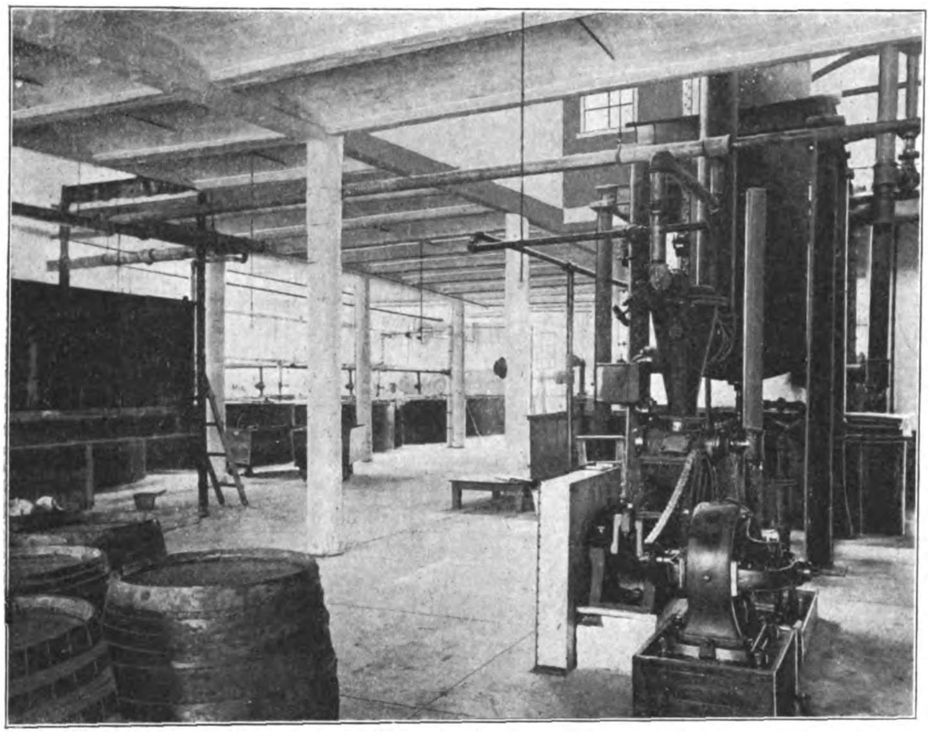

FIG. 15.—VIEW IN SOAP FACTORY SHOWING GLYCERINE PLANT.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.

The International Association of Municipal Electricians held their eighth annual convention at Atlantic City, N. J., September 2, 3 and 4. The headquarters of the Association were at the Hotel Rudolf, the session being held in the ball-room. Many representatives of the manufacturing and supply interests connected with the electricians were present, and the convention opened with the largest attendance ever accorded to the association. The delegates were welcomed by F. P. Story, who as mayor of the city, granted the members and guests its freedom. Suitable response was made, and the business of the convention was taken up. A very interesting program had been outlined, and this was carried out to the satisfaction of the committee in charge and the members in attendance.

Mr. Austin S. Hatch, of Detroit, Michigan, contributed an interesting paper entitled, "Records and Reports," in which he urged municipal electricians not only to make records of every official action, but also to record conversations having relation to their duty. The paper includes a set of rules and regulations for the construction and maintenance of electrical wires. A system is also sketched in which to base city reports, and another relating to details connected with new work and repairs, and for keeping a record of work.

Mr. W. H. Townsend, of Richmond, Va., in a paper on the importance of the fire alarm and police telegraph, showed how with a proper fire alarm system the losses caused by fire might be greatly reduced and also pointed out the benefit of a police patrol system to a community.

"The Economy of Time" was the subject of an interesting paper presented by Mr. Henry W. Pope, in which was elaborated the importance of the telegraph and telephone in modern life. Referring to the time list in sending telegraph messages to and from offices, the author suggested the use of blank forms for the reception of the typewritten message which could be folded and sealed to show the address, eliminating the necessity of an envelope, and the labor, time and expense involved in providing and addressing it; or an envelope with a space cut out of the face side and covered with transparent paper, so that when the telegram was properly folded the address could be read from inside the sealed receptacle.

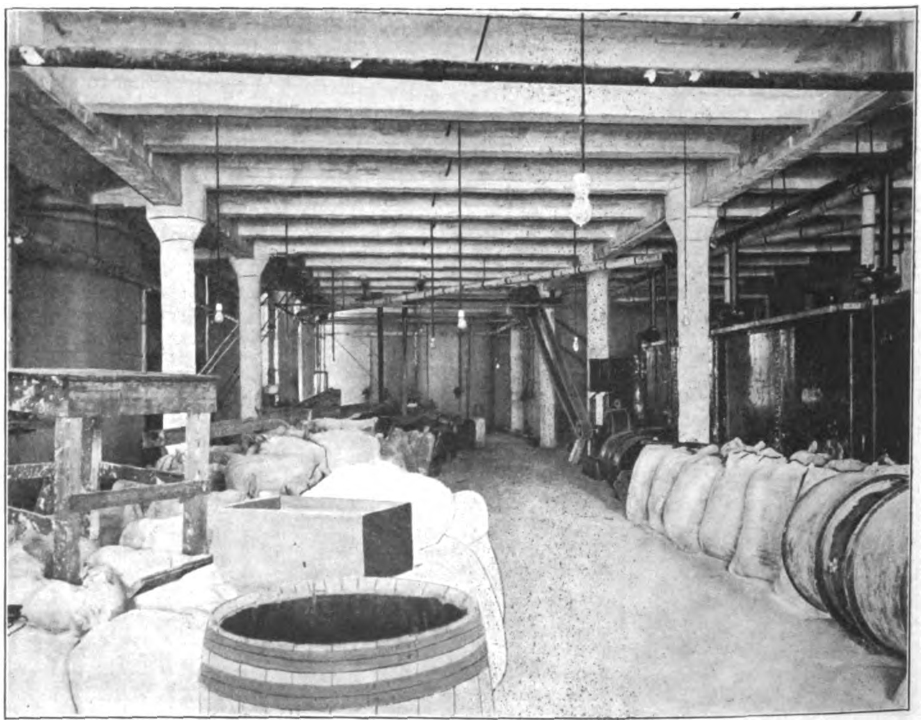

FIG. 16.—FLOOR IN SOAP FACTORY CONTAINING MOTOR-DRIVEN CRUTCHERS AND MIXERS.

In filing the telegram for transmission the sender should be asked to elect whether the delivery should be made by telegraph or telephone, and this indicated by some character or symbol would be the authority for the distant office.

Mr. Pope considers that the time is not far distant when the existing conditions with regard to the collection and delivery of telegrams, or even the more improved conditions suggested, in which the telephone is utilized, will be considered indirect and cumbersome to large commercial users of the telegraph, unable for one reason or another—principally expense—to avail themselves of the advantages of a private wire. The demand for a service that will fill many of the requirements of a private wire and reduce the time element still further will bring into use an automatic service which will be in entire control of the sender and receiver of communications, as is the case to-day with long-distance telephone service, the company performing no part of the operating service in the actual transmission and reception of the message except furnishing and maintaining the wire and apparatus.

The almost general use of the typewriter, with its universal keyboad and its skilled attendant, meets the operating problem, and it is easy to conceive that with a simple apparatus or punching mechanism this employee is in training to become the operator of the future in punching transmitting and translating type, or for the work of operating simple printing devices or any device possible of operation with a universal keyboard. The connection would be put up on order as is now done in a telephone transaction. The message, having been prepared by the stenographer or typewriter, is transmitted to the distant customer at the rate of hundreds of words per minute, and they are translated by the customer's employee. The charge for this service, in which the company or its employees take no part other than providing the circuit, leasing and maintaining the apparatus, would seem a possibly cheaper method than the present telegram charge, in that the labor of operating is borne by the customer, and the limit as to the number of words is practically removed.

All telegraphers understand why the Morse system holds its own against all suggested automatic schemes. The automatic as understood to-day is a wire-economizing device more than anything else. The scheme outlined eliminates, so far as the company is concerned, the time and inconvenience of preparation and delivery—the labor and stationery—of an ordinary telegraph transaction. The author has often wondered why this sort of system has not suggested itself as of sufficient importance to justify an experimental trial. Mr. Pope advocated the installation of private branch exchanges with ample trunking facilities when the telephone is largely used. Interior services between stations is free and unrestricted. The chief officer is within speaking distance of every department or subordinate, and the time usually occupied and the inconvenience experienced in getting from one department to another is saved. Some corporations go so far in the broadening of this system as to provide telephones for their clerks; the convenience and time saved justify the expense, which at best, is nominal after the exchange is once established.

It does not follow that the installation of a private branch exchange involves increased telephone expense. Oftentimes a considerable saving can be effected by the elimination of high-priced direct exchange connections, and passing such service through the private exchange. Such an exchange, operated by one's own employees, could handle fire and police calls originating through telephone channels with reliability and promptitude. With direct trunk wires, for emergency purposes only, from each city exchange to this private branch exchange, it must be obvious that the field of operation and protection would be enormously increased.

A. Frederick Collins gave a very interesting lecture and demonstration of space telegraphy and telephony, explaining in detail the apparatus and method of using the latter, illustrated by working models. A demonstration was also made of the Cooper Hewitt mercury vapor lamp and static converter by Dr. M. von Recklinghausen, assisted by P. Thomas.

The officers elected for the ensuing year are A. C. Farrand, president; W. M. Petty, first vice-president; G. F. Macdonald, second vice-president; F. E. Pierson, third vice-president; F. A. Cambridge, fourth vice-president; F. P. Foster, secretary, and A. Busch, treasurer.

Convention of the American Street Railway Association

This year's gathering of street railway men at Saratoga Springs, N. Y., September 2, 3 and 4, was satisfactory not only because of the large attendance and interest displayed in the proceedings, but because of the fact that three conventions were conducted at practically the same time. These included conventions of the American Street Railway Association, The American Railway, Mechanical and Electrical Association and the Street Railway Accountants' Association of America. The American Street Railway Association was, of course, the principal factor, but the other associations came in for their share of attention. The list of papers prepared proved to be one of the most attractive ever presented, and taken altogether the meetings of the organizations were thoroughly satisfactory in every respect. We regret that space limitations preclude the publication of the entire proceedings, but abstracts of such papers as fall within the scope of the American Electrician follow.

W. CARYL ELY,
President of American Street Railway Association.

Improvements in Street Car Motors.

This paper, presented by Mr. E. W. Olds, contains a number of advanced ideas the author has advocated for street railway motor work for several years. It is only necessary to look back a few years to see that improvements in street-car motors have been made at a very rapid rate. Manufacturers and designers have not been idle. Reliable equipments are now obtainable, the motors being constructed practically waterproof, with the gears entirely enclosed and well lubricated, and the controllers being practically all series-parallel. Some of the street railway companies have had and are having special motors built according to their ideas and to meet their conditions. One of the weak points being covered by the manufacturers and railway companies in their special machines is the construction of the motor frame to make it more accessible for inspection and repairs. Almost all street railway motors, as now designed, are arranged to open at the bottom, so that practically all of the repair work is done in a pit. In repairing the double truck equipment, it has been found more satisfactory to lift the car body from the truck, making it possible to do all of the repair work from the top. To do this, the top half of the motor frame should be designed to lift off, so as to give access to the armature bearings, fields, brush-holders, etc.

E. W. OLDS,
President of the American Railway, Mechanical and Electrical Association.

The dimensions of gears have not been increased in proportion to the motors. They show excessive wear, causing very often the swedging of the teeth. This should be remedied by making the gears with a wider face. The quality of the steel should be closer grained and tough, thereby increasing the life of the gear with but little additional cost. Gears at present last from eighteen to twenty-four months, and the pinions from twelve to eighteen months, and the author contends that this should be increased 100 per cent. The advisability of using split or solid axle gears is an open question. If split gears are used the bolts should be made larger and provided with nut locks, double nuts and cotters, making it impossible for them to become loose and fall out.

The gear case should be so constructed that it will stand abuse as well as use, and in order to make such a case it would be necessary to cast it as a part of the lower half of the motor frame, doing away with bolts and giving the gears absolute protection. The armature bearings should be made longer and larger with linings that may be easily removed and either babbitted or renewed. This, the author believes, would make a saving of 50 per cent in the bearing expense. Lubrication is also a very important matter. Until recently, nearly all street-car motors have been designed to use grease. Some manufacturers have used both grease and oil, feeding the oil with a wick from below and grease from cups above the bearings; bearings have also been designed to use only oil which is fed from wool waste or wicks placed in oil wells below the bearings, both of which have been very satisfactory. Cheap grades of babbitt metal should not be tolerated. It is necessary to have a metal that is hard, tough and close-grained. Since the motors must necessarily run more or less in dust, a soft or open-grained metal will hold the small particles, thus causing excessive wear of the shafts. The average life of bearing linings in city cars at present is about six months; this should be increased to not less than one year. On interurban cars the average is about eight months, and should be increased to eighteen or twenty-four months.

The contact between commutator and carbon brushes should certainly be improved. This can be done by making the commutator bars longer and deeper, giving better contact with the brushes and longer life. The author says the best manufacturers do not produce a carbon brush that is always reliable, the brush being very often either too hard or too soft, which makes poor contact and causes the commutator to become rough and black, thereby causing the motors to become overheated, burning out the armatures and fields. A better connection should also be made between the carbon brushes and brush holders. Motors have been constructed to use the so-called "pig-tail"; some users report that this is very satisfactory, and others that it is of no value whatever. Without the "pig-tail" the current is practically all carried by the brush hammers and springs, often causing the springs to become overheated, destroying their tension and making poor contact between commutator and brush.

One of the weakest points of street railway motors is the insulation of the wire used for field and armature coils. There have been a great many experiments made to find a satisfactory substitute for the cotton covering, but nothing better has been found. After all the skill and thought that has been put upon street railway motors to make them perfect mechanically and electrically, it seems too bad that one is obliged to use the same cotton covering one did years ago, as their electrical life depends to a very great extent upon the production of an insulation that will not carbonize. The motors must be improved with the balance of the equipment. The high speed and quicker acceleration make the strain greater, and motors must be designed to meet the conditions; ever keeping in mind that the cost of maintenance must be as low as possible.

The Milwaukee Electric Railway & Light Company has had designed and manufactured for its city and interurban service, motors embodying some of the special features suggested. The gear case is made more substantial and is well secured with bolts to the motor frame. The motor frame itself is constructed in two parts, the top half of which can be removed by loosening four bolts. The axle and armature bearings are constructed with oil wells, packed with wool waste, and are lubricated with oil. For city use the axle bearings are 5 inches, and for interurban service 5½ inches. Armature bearings are made larger and longer, the commutator end increased about 30 per cent and the pinion end about 16 per cent. The commutator is made longer, increasing the contact surface 20 per cent, and the depth of bars is increased 30 per cent. The gear fit is made ½ inch larger than the body of the axle. The face of the gears is increased about 15 per cent. The brush holders, their springs and hammers are better insulated and made more durable. The construction and insulation of all electrical parts have been given careful consideration to bring them to as high a degree of perfection as possible.

The Use and Abuse of Controlling Mechanism.

This paper, presented by D. F. Carver, presupposes that the driving and controlling machinery of the rolling equipment has been bought and installed in a manner best adapted to meet the special conditions of service, which vary on many roads, subject to local conditions of grade and alignment, operating management, stops and starts to be made, vehicle traffic to be avoided, acceleration desired, and laws and restrictions imposed by the community through the municipal government. With the machinery at hand properly designed to work under the conditions imposed, it is not a difficult matter nor an expensive one to keep the controlling mechanism in first-class condition and prevent it from depreciating in running value to its owners at a faster rate than has been caused in the past by the progression in the art of design and construction of operating machinery.

It now seems probable that the present type of magnetic blow-out controller for city cars has come to stay, and that the future changes in it will be only in detail, so that it is a good investment to spend necessary money in maintaining these controllers and keeping their depreciation through wear and tear as small as possible; and it is good railroading to watch them and care for them and protect them from the abuse which they too often get from inexperienced and untrained handling while being in use on the road. It is not often that machinery breaks down as did the Deacon's one-horse chaise; it gives indications and warnings beforehand that something about it is not doing the right thing, and it is necessary to provide methods so that the first indications of internal trouble may be made known. After that there must be provided the experienced inspector who is trained to know what causes the peculiarities he discovers, and he must know how to remove the cause of trouble. Several times every day, while the cars are at once off the suburban terminals the controller cases should be opened and the whole interior mechanism given a hasty cleaning and a little lubrication of the contact fingers with a good quality of refined lubricant, vaseline being one of the very best, though somewhat expensive.

A somewhat common form of abuse for which no one in the service can be held directly responsible is due to the fact that, on many of the roads, there are now running small equipments which were designed to haul small cars and small loads. The great growth of traffic which has come so rapidly on the trolley systems was not anticipated ten years ago, so many are in the position of having a large number of equipments partly worn out, which are always overloaded by any loads they now have to carry; consequently, they are running on roads mixed with motor equipments of recent design and ample strength, and the poor, old inadequate equipment must be driven along out of the way of the new and fast cars, and it usually gets all the abuse of heavy loads, fast schedule and frequent stops; it runs along somehow, because it was so well built that it takes its own time about failing.

Shop Kinks

was the title of a paper delivered by Mr. H. H. Adams, who submitted a few ideas covering the things he had found useful in a repair shop. Among the numerous kinks described were an arrangement for unloading cars, an armature cart, a trolley-pole straightener and methods of insulating fields and making induction tests for short-circuits in armatures.

The question of unloading cars from railroad flats is one which most railways have to contend with, and in the majority of cases this is done with some make-shift device, frequently at the expense of a long operation and attended with more or less danger. A simple device for unloading cars consists of four upright posts 12 inches x 12 inches placed two on each side of the track with sufficient clearance to pass all types of steam railroad cars. A 12-in. I-beam is framed into the top of each pair of posts, and the posts are tied together across the tracks at the top by means of tie-roads, using pipes as spacers. The pipes are also fastened to the posts by flanges and lag screws. On each I-beam there are two 7000-lb. chain hoists, which are suspended from rollers by means of a U-iron. The connection between the lower hook of the hoist and the truck consists of a flat bar 1 inch x 4 inches, bent into the form of a square hook to fit the side of the truck, with an eye at the upper end. This hook is made of a flat bar, in order to allow it to be slipped into the opening between the top of the toe-board and the bottom of the sill-plate. One hundred and ten open cars on trucks were unloaded, the average time required being ten minutes to the car with a gang of six men, this time including the placing of the car in the shop and the shifting of the railroad flat car outside of the yard. The whole cost of erecting this device did not exceed $100.00.

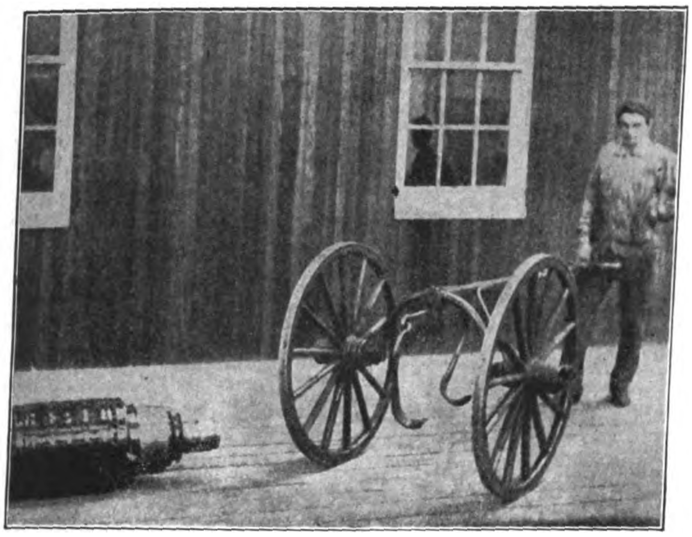

FIG. 1.—ARMATURE CART.

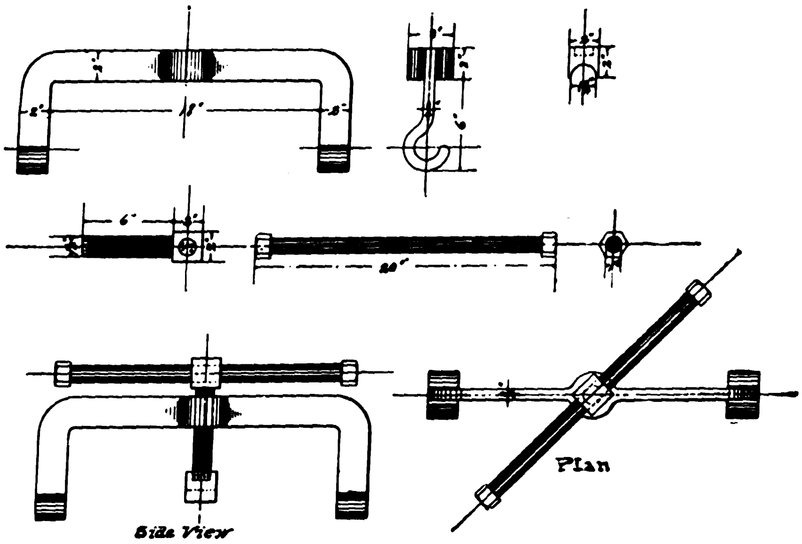

FIG. 2.—DETAIL, SIDE ELEVATION, AND PLAN OF A JIM CROW.

An armature cart is illustrated in Fig. 1. The armature is carried at a good height from the floor, and as the wheels of the cart are 36 inches in diameter, it is moved very easily from place to place. A cart of this kind removes the necessity of rolling an armature on the floor, a practice that is dangerous in the cleanest shop. As soon as the armature is removed from the motor it is placed on one of these armature carts and carried just outside the building, where there is an attachment for cleaning the armature with compressed air. The armature may be readily revolved in the hooks on this cart without placing the same on the ground, and in this way compressed air is blown into all the openings in the armature, thus cleaning out all the carbon dust that it is possible to reach in this manner.

A small Jim Crow is a very useful device about a repair shop or car house. Fig. 2 shows one which may be used to straighten trolley poles, dash-pots, etc. It is not too heavy to take on the roof of the car, and the trolley pole may be straightened without removing it from the stand.

The question of re-insulating fields is one which has been before the electric railway repair man for some time. In using the re-insulating machine for this purpose, great care must be exercised not to stretch the wire excessively in putting it through the machine. The tension placed upon the wire in order to straighten it must be as light as possible. Fig. 3 shows another scheme for re-insulating fields, the wire of which is too heavy to be handled by a re-insulating machine. The field which is burned out has its exterior cover removed, and if it is badly charred it is taken outside the building, and as much of the insulation and dust removed as can be blown by 80 pounds of compressed air. The field is then placed on a long wooden bar, opened up and stretched along the same. The insulation which remains on the wire is cleaned off by hand with the use of scrapers. After being thoroughly cleaned the new insulation is placed on the wire by hand; this being accomplished the field is assembled beginning with the inner turns and following turn for turn to the outer ones, as shown in Fig. 3. The field is then recovered and ready for service.

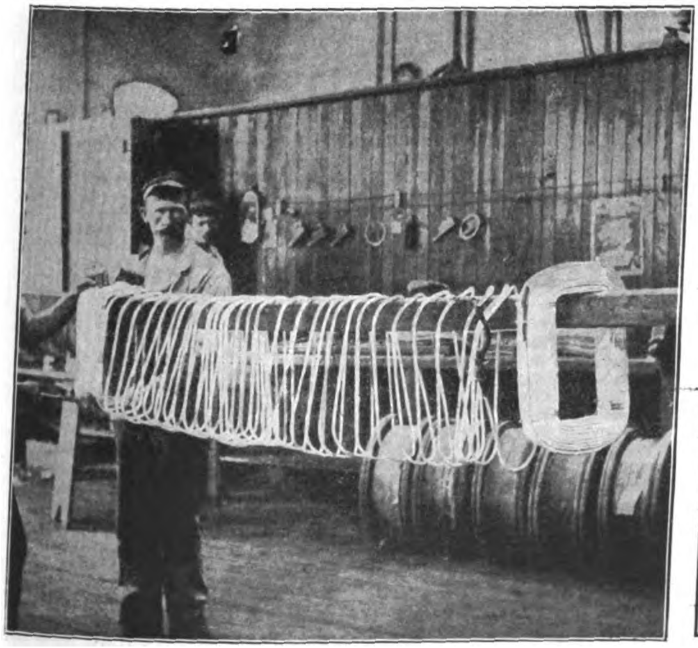

FIG. 3.—RE-INSULATING FIELD COILS.

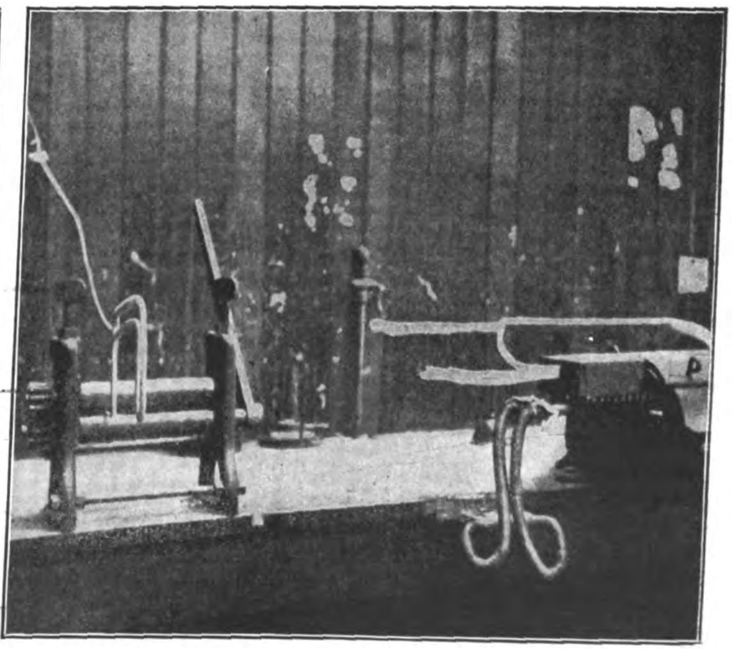

FIG. 4.—DEVICES FOR MAKING ARMATURE COILS.

In making induction tests for short-circuits in armatures, the apparatus used consists of an old Baxter motor field suspended between two uprights and balanced by a counter-weight, so that it may be adjusted to conform to the various heights of the different armatures. This field is wound with No. 9 wire, and supplied with alternating current from a small belt-driven alternator. The armature is placed in the magnetic circuit of this field, and revolves slowly, and a small tell-tale piece consisting of a light piece of sheet metal is held at the top of the armature. If there are any short-circuits, these will be easily determined by the vibration set up in the tell-tale piece, which can be readily felt by the hand. A device of this kind is one of the greatest money-savers possible to put in an armature repair shop, and it will save many an armature from being needlessly burned out, as the short-circuits can be detected in the shop instead of their developing after the armature has been placed in the motor. Fig. 4 illustrates two devices which are used in connection with the making of armature coils. The one shown on the right-hand side of the illustration consists of an ordinary vice to which is attached cast-iron jaws. The jaws are each heated by a gas burner. This device is used in drying the glue which is employed in fastening the insulating cell of the coil. It is also used as shown in the illustration in pressing two coils together where the coils are to be assembled in this manner. The device dries out a large amount of moisture and puts the coils in shape to be taped. Various lengths of jaws are used for the different types of coils. The device on the left-hand side of the illustration consists of a pair of rollers, these being used to flatten the leads of the coils, and by a very simple trick removes at the same time the insulation of these leads instead of having it scraped off by hand, as is usually done. This is accomplished by the use of a little glue upon the rollers.

"Type-M" Control.

The title of Mr. W. O. Mundy's paper would at first sight seem like an advertisement of a particular company's controlling apparatus, but such is not the case, the paper treating more particularly of train control. There are but three recognized systems of control in use in this country, namely: The Sprague pilot motor control, the Westinghouse electropneumatic drum control and the General Electric type M control. Considering these three in order, the author finds that the Sprague Company, owing to its absorption by the General Electric Company is no longer pushing the pilot motor control, and in fact, before the consolidation had proposed and was advocating a scheme somewhat similar to the contactor system. He therefore drops the pilot motor control from the discussion, considering it as not being up-to-date. Referring to the Westinghouse electropneumatic drum control, he finds that the manufacturers are no longer advocating the same, but have recently placed upon the market a turret controller. Owing to the fact that the Westinghouse Company was not ready to give to the public details of the system, consideration of it was impossible. This unfortunately left only the type M control for discussion.

It is safe to say that in no part of the electrical equipment of cars are the effects of the different conditions imposed by the constantly heavier and faster cars being put into service more markedly shown than in the operation of the controllers themselves. Apparatus that is almost ideal when used on motors of comparatively small power has been both enlarged and strengthened to meet the more severe conditions, and yet the very best of construction has failed to be entirely satisfactory. Consequently the majority of us are looking for something better. Undoubtedly, the principal causes of troubles are that the necessarily heavier working parts of the controllers must move more slowly, and the arc is therefore longer in being broken. That combined with the greater amount of metal vapor caused by the larger currents makes the arc harder to break, even if the voltage is no higher, yet in the majority of cases we are compelled to use higher voltage in order to give the proper service. These three causes combine to make a most serious one to meet, and is without doubt the reason that while the Sprague controllers were very successful in Chicago when used with 80-h.p. motors, they were not nearly so satisfactory when used in Brooklyn and Boston with 160-h.p. motors; hence the new electric switch control proposed by the Sprague Company before its absorption.

The type M control consists of a number of electrically operated switches or contactors for making the motor current connections, the contactor being controlled in turn by a small master controller operated by the motorman. The only current passing through the master controller is the small amount necessary to operate the contactors, and as the contactors on every car are connected in the same kind of groups and these groups in multiple, the operation becomes the same whether one or more cars compose the train, the only difference being that the master controller in use must handle an additional amount of current for each car attached to the train. The operation of the motors themselves, however, is identical and simultaneous from necessity, no matter in what part of the train they may be. The apparatus has been so well described in the technical journals that the author does not give any further details.

While developed particularly to meet the conditions of train control, the type M apparatus has created for itself many other uses. It is of necessity more complicated than an ordinary series-parallel control, but possesses some advantages that give it a field outside of train use. As nearly all the weight can be placed under the car body the platforms have much less to carry, besides making more room for passengers, and inasmuch as the motorman has a much smaller handle to operate and there is so much less work to do he should do it more carefully, but whether he will is quite another matter.

Electric Welded Joints.

A paper having this subject was presented by William Pestell. Probably nothing contributes more to the expense of operating an electric railway than bad joints in the track. First comes the wear and tear on cars, trucks, motors and equipment from the constant pounding; the loss of voltage due to the breaking of bonds, with its inevitable consequence, baked-out motors, reduced schedule speeds, increased coal consumption and chances for electrolysis; then the expense of taking up paving, renewing splice-bars, bolts, etc., in an almost hopeless attempt to making the rail fit for further service. It is usually found that by the time a general overhauling of the track is decided upon the rail-ends are so badly pounded out that the simple raising of the joints and renewing of splice-bars and bolts do not extend the life of the rail to a commercial practical extent. This is particularly so in the case of girder rail in paved streets. T-rail is usually more accessible and less costly to repair, consequently does not get into as bad condition before repairs are made, and can, by the use of some of the patented joints, be put in such a condition that many years are added to its useful life.

The first welds used under the patents of Prof. Elihu Thomson were made by welding a short, vertical bar directly over the joint. This weld was made under pressure, but the pressure was not continued after the weld was completed, and the metal in cooling became porous, and left a mechanically weak joint. After a great deal of experimenting it was found that by making the weld under pressure and increasing the pressure as the weld was completed, continuing it until the weld had practically cooled, that the metal was left in a dense condition, free from porosity and having a high tensile strength. This led to the making of projections or bosses on the bars, the bars being placed one on each side of the rail, and welded in their places directly to the web of the rail, the center weld being made through a loose piece of metal dropped on the bar, rather than a boss.

The welding plant consisted of a sand car, welding car, rotary converter car, booster and motor car, and motor and emery-wheel car for finishing. Recent improvements have reduced the number of cars from five to four, and instead of regulating on the direct-current side of the rotary transformer by a motor generator, the regulating is done on the alternating-current side by means of variations in the connections of a regulating transformer. At the present time the welds are made by two steel bars, the usual size of which are 1 inch x 3½ inches, and from 18 inches to 48 inches long, 18 inches being the shortest bar found practical to weld even where the holes are not drilled in the rails, the greater lengths depending on the distance of drilled or punched holes from the end of the rail. It is not safe to weld on bars where the holes are nearer than 3 inches from the end of the bar. The same size of bar is used on both 6-in. and 9-in. rail, the strength of the bar being ample to support the joint directly at the weld without the bar mechanically fitting the rail. In welding rails expansion is ignored, since the elastic limit of the steel can never be reached when rails are firmly embedded in the paving under the extremes of temperature encountered. As an instance of the saving effect the author cites a case where improvements made in tracks, including new rail and bonding, electrically welded joints and supplementary cables, reduced the track loss about 75 per cent. The cost of removing paving, welding joints, replacing paving and cleaning up the street is variously estimated by the roads which have done the most welding, at from $2,000 to $2,500 per mile, on a basis of 30-ft. rail length. These figures do not include renewal of railway ties.

From results obtained on electrically welded old track it is obvious that this method is equal to any other known method for extending the life of the rail, decreasing the repair bills for track and equipment, and lessening the electrical losses.

Following are the officers-elect of the American Street Railway Association and affiliated bodies:

AMERICAN STREET RAILWAY ASSOCIATION.

President, W. Caryl Ely; first vice-president, Edwin C. Foster; second vice-president, John Grant; third vice-president, James F. Shaw; secretary and treasurer, T. C. Penington. Members of the executive committee: J. C. Hutchins, A. B. Colvin, G. Tracy Rogers, W. A. Smith and S. L. Nelson.

AMERICAN RAILWAY MECHANICAL AND ELECTRICAL ASSOCIATION.

President, E. W. Olds; first vice-president, Alfred Green; second vice-president, C. F. Baker; third vice-president, W. O. Mundy. Members of the executive committee: T. J. Mullen, H. H. Adams, D. F. Carver, H. J. Lake. Secretary and treasurer, Walter Mower.

STREET RAILWAY ACCOUNTANTS' ASSOCIATION OF AMERICA.

President, F. E. Smith; first vice-president, F. R. Henry; second vice-president, C. O. Simpson; third vice-president, J. J. Magilton; secretary-treasurer, W. B. Brockway. Executive committee: H. J. Davies, O. C. Rogers, S. G. Boyle and H. M. Pease.

Abstracts from Foreign Contemporaries

Renewable Wehnelt Interrupter.—In a recent number of the *Annalen der Physik*, L. Zehnder describes the Wehnelt interrupter shown by Fig. 1. Referring to the illustration, *M* is a brass tube containing the brass rod, *S*, which bears at its lower end the platinum point, *P*. *L* is a lateral perforation of the tube, slit as shown, so as to guide the rod, *S*, in its vertical adjustment. The lower end of the brass tube is closed with a steatite, perforated to let the platinum wire pass. A rubber tube is slipped over the brass tube, and over that again is put a glass tube which presses the rubber tube tightly against the stone. With this arrangement, the acid can do no damage unless it penetrates through the steatite to the brass rod. This only takes place when the perforation of the steatite becomes widened, as it does in course of time . It is, therefore, necessary to renew the bit at intervals, which can be done cheaply. The negative electrode is a lead plate, or a lead worm through which cold water is driven. As an additional precaution, the brass tube may be replaced by a copper tube covered with lead. The lid, *H*, may be of wood, paraffined and lacquered.

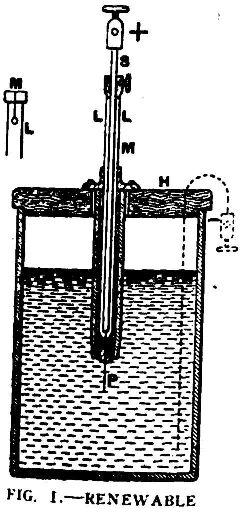

FIG. 1.—RENEWABLE WEHNELT INTERRUPTER.

Electric Elevator Mechanism.—London *Engineering* describes in a recent issue the motors and gearing of an electric elevator which has been designed, as, in fact, all elevator mechanisms usually are, with a view to ensuring the absolute safety of not only the elevator and its contents, but also reliability of operation. In the case under discussion the motor is a shunt-wound machine, but it is provided with some heavy series coils which increase the torque at starting, and so enable the elevator to get under way rapidly. The whole of the working parts are entirely enclosed. The shaft of the motor carries on its outer end a brake-wheel, and between this brake-wheel and the armature is a worm gearing with a worm-wheel keyed to the same shaft as the lifting rope drum. The normal position of the brake is "on," the necessary pressure being secured by a weighted lever. The mechanism is controlled by a rope passing round a rope wheel. The shaft on which this wheel is mounted carries a cam which, when the wheel is rotated to start the elevator, raises the brake weight through a chain and lever, leaving the armature free to revolve. The motion of this rope-wheel shaft is limited in each direction by a stop. At its inner end this shaft gears by bevel wheels with a switch shaft, on which are mounted two switches; one of these is the reversing switch, whilst the other is the actual circuit-closer. The arrangement is such that the reverse switch is closed in the desired direction before the other switch completes the circuit, hence the contacts of the reverse switch do not suffer from sparking, since they are never opened or closed when current is passing. The main switch, however, at which the circuit is broken, is provided with a magnetic blow-out, which is shown in position in Fig. 2. This blow-out effectually prevents arcing. Above the switch shaft will be seen an arm pivoted to the left of the switch casing, and carrying at its other end contact pieces which can pass over the starting resistance contacts shown to the right of Fig. 2. In its present position the current is off; and the arm is held up by the small roller indicated. As the switch shaft is turned round, however, this roller passes from under the arm, leaving it free to fall by its own weight. The dashpot shown, however, causes the rate of fall to be slow, so that no matter how abruptly the starting switch is thrown over, the rate at which the starting resistances are cut out is unaltered, thus making it practically impossible to burn out the motor armature or blow the fuse by too heavy a starting current.

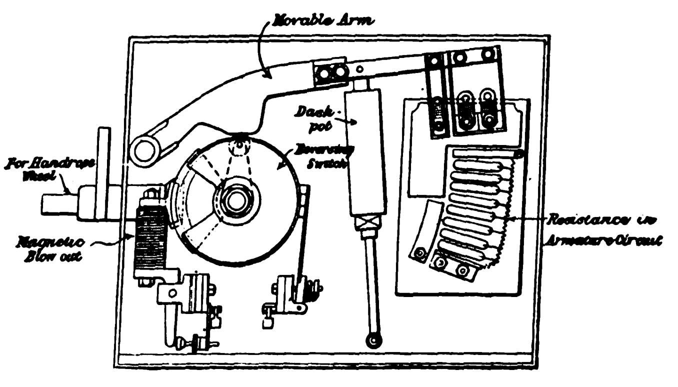

FIG. 2.—ELECTRIC ELEVATOR MECHANISM.

High-Tension Oil Switches.—In a paper read before the German Electrotechnical Society, Gustav Benischke describes a high-tension switch constructed by him and illustrated diagrammatically in Fig. 3. The author found that when large currents were interrupted under oil, two conditions have to be fulfilled; first, no air must be allowed to get to the interruption spark, and, second, the oil must enter with a certain pressure between the contacts the instant the current is interrupted, so as to suppress the arc at the moment it is generated. If these conditions are not fulfilled, it may happen that so large an amount of oil is carbonized between the two contacts that a conducting bridge is formed. In the switch designed by the author the leads are introduced through the lid of the case of the switch, and are connected by a piece, *M*, when the switch is closed. The opening of the switch takes place by moving *M* downward, where-

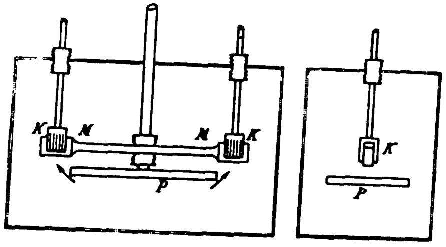

FIG. 3.—HIGH-TENSION OIL SWITCH.

by the current is interrupted simultaneously at both contacts, *K*. A wooden plate, *P*, is connected to the piece, *M*, which, when the latter is pushed down, forces the oil up towards the contacts, thus breaking the arc before it has reached a length of 2 to 3 mm. The carbonizing of the oil and the burning of the contacts is thereby minimized.

Electric Shock.—In a paper read before the Verein Deutscher Revisionsingenieure, Dr. Kath treated of the conditions for the safety of the men driving electrical plants. Direct current, he pointed out, will, as a rule, become really dangerous only in the case of several unlucky circumstances being present at the same time, as its tension seldom exceeds 500 volts. Direct-current machines should be enclosed tightly, so that sparking, liable to endanger the surrounding medium, is prevented. As regards the properties of the human body, the author draws attention to the fact that an electric shock will essentially act on the nervous system, as the nervous substance is a conductor of electricity surrounded by less conductive fat and muscle substance. The paths most frequently followed by the current in the case of accidents will afford an evidence as to which nerve strings are most likely to be struck, which functions most liable to be paralyzed, as being controlled by these nerves. In the case of the shock entering by a hand or the head and leaving by the other hand or a foot, the nerve descending from the neck and leading to the lungs and heart—the so-called *nervus vagus*—will be struck, and as the latter regulates both the respiration and the action of the heart, respiration will first be stopped, and the action of the heart will eventually cease in the graver cases. A shock entering by the points of the fingers and leaving by the upper arm, however, will, as a rule, not be attended by fatal results, the above nerve not lying on its way. The best assistance in the case of an accident will be rendered in the way of producing artificial respiration, enforcing the heart action and diminishing the pressure of blood, the latter being obtained by injecting one to three drops of amyl nitrate. The dangers of electric currents will, moreover, vary to a high degree according to personal predisposition, persons subject to alcoholism, as well as those easily frightened, suffering much more from the effect of electric shock than normal people. The limit of danger is considered as coinciding with 0.1 ampere.

Motor and Dynamo Troubles.—In a paper entitled "Electric Plant Failures: Their Origin and Prevention," read before the British Institution of Mining Engineers, A. C. Cormack gives an analysis of the breakdowns which have occurred in the past four years to several thousand motors and generators ranging in size from a ½-h.p. motor to an 800-kw. generator. The figures given in the accompanying tables are for machines which have received more than average attention, so that the figures are considerably above the average. Table I summarizes the nature of the accidents; the points of origin of the different breakdowns are shown in Table II., and Table III. gives a summary of the ultimate causes of the failures. The per cents in all cases refer to the total number of failures covered by the tables. Of the accidents in which the field-magnet coils were damaged (Table I.) the larger number were cases in which the insulation between the coil and cores had given way. The 1.56 per cent representing coils gone altogether—that is, arcing from series to shunt on the same coil or arcing between two separate coils—shows that this is not an altogether uncommon accident. The latter accident is most frequently met with in bipolar machines where the coils often touch. In this case, unless the outer layers are at the same potential, there is considerable risk of accident. The failure of armatures constitutes by far the most serious item in the table. The form which such a failure most frequently assumes is the burning out of coils. In many cases the entire armature is burned out, and in others only a few coils. The percentage of coils gone to earth—19.5—is also a large item, and most of these failures are due to destruction of insulation. The accumulation of dust or other conducting material on the insulating ridges, such as is met with at the outer end of the slot insulation or at the end of the coil supports of a barrel-wound armature, accounts for the majority of the remainder. Breakages of wire were confined mainly to the smaller sizes of wire-wound armatures and usually took place at or about the points where the wires leave the coils or join the commutator. The 3.1 per cent in which binders were burned are those cases where fusing took place by arcing between the binder and armature wires and did not arise from purely mechanical stresses. Commutators are frequently damaged, this having occurred in 33.6 per cent of the breakdowns. The failures of commutator insulation have for the most part occurred at the ends, causing leakages to the earth-connected portions of the commutator or between bars or radial connections. In the majority of cases these failures are caused by the presence of dirt or other foreign matter on the insulating ridges or between the radial connections. The mechanical failures of commutators, amounting to 10.95 per cent, consist of burst commutators, fracture of commutator lugs and failure of keying of commutators. The cases where surface fusion of a commutator has occurred are cases where the surface of the commutator has been destroyed by violent sparking. Table II. is interesting as showing the parts of the machines which originated the failures. Breakdowns to shafts were caused generally by the armature getting out of center through wear of the bearings, so that the unbalanced downward magnetic pull added to the weight of the armature produced a severe bending moment in the shaft. These causes are properly chargeable to the bearings. An interesting defect in dynamo and motor bearings, which sometimes occurs and requires watching to prevent damage, is the wearing of the bearing upwards. This sometimes occurs in cases where the armature has been placed nearer the top of the race than the bottom in order that the upward pull of the magnets may relieve the pressure on the bearings. When the upward pull of the magnets is greater than the gravitational attraction, the bearings wear upwards and permit the armature core to approach the pole-tips when working. This, owing to its liability to escape detection, is a somewhat dangerous defect, for when the machine is examined at rest the armature clearance will appear satisfactory. Most of the joint failures in wires are caused by bad workmanship. Commutators are responsible for 14.9 per cent of the breakdowns, and these are divided into two classes. The first, in which the insulation has broken down, most frequently occurs between the bars and supporting rings, the parts subject to the greatest difference of pressure. Such breakdowns often result in the burning out of the armature windings. To a much slighter extent a breakdown of insulation between the segments occasionally occurs; this seldom results in more than a few coils being damaged. Only in a very few cases does a breakdown occur in the body of the insulation, permitting flashing through it. These few cases have all occurred where a material which absorbs moisture had been substituted for mica. Almost all the accidents to commutator insulation are due to the collection of oil, dust, etc., on the insulating ridges separating the segments from the clamping nuts. In many cases these ridges are made much too short. Sometimes there are no ridges at all, the insulation being flush or even sunk below the level of both bars and rings. The insulation at the outside end is usually most exposed to such accumulations, but being more readily cleaned, fewer breakdowns appear to occur here than at the back end. Very few cases have occurred where insulation has broken down owing to the commutator wedging arrangements slacking back and permitting sufficient chattering to pulverize the insulation. The defective fastening and keying of the commutator have caused 5.5 per cent of the total number of accidents. Bursting of the commutator by centrifugal force is not now so common as it used to be, and few cases are met with; these are usually due to improper locking arrangements. A case of burst-

TABLE I.—Relative Frequency with which Various Portions of Dynamos and Electric Motors were Damaged in Breakdowns.

	Per cent.	
Mechanical portions:		
Broken shafts	2.35	
Binders and fasteners	9.40	
Bearings	8.60	
Other mechanical parts	4.70	—25.05
Brush-gear, connections, terminals, etc.:		
Failure of brush insulation	2.35	
Connections and terminals	3.10	
Mechanical portion of brush-gear	1.56	— 7.01
Field magnet coils:		
Coils burnt out	5.50	
Coils earthed	3.10	
Coils gone altogether	1.56	—10.16
Armatures:		
Coils short-circuited and burnt out	29.00	
Coils earthed (that is, failure of insulation of frame)	19.50	
Breakage of wire	15.60	
Joint failures	8.60	
Binders burnt	3.10	
Driving horns	2.35	—78.15
Commutators:		
Failure of insulation	10.15	
Mechanical failures	10.95	
Surface fusion	12.50	—33.60

ing of commutators which does not figure at all in this table is that where the bars have been allowed to wear down too far. The defect or absence of keying of the commutators has caused in this class the largest number of breakdowns. Where the keying is defective the commutator is driven by the armature wires, and sometimes the commutator and the armature have a slight relative motion on the shaft. This has caused a large number of the breakages of the wires joining the armature to the commutator. Starting switches of motors have been the cause of 4.7 per cent of the breakdowns in the table. A not uncommon fault in starters, which has caused the burning out of armatures, is the breakage of the wire near the last stop, subjecting the armature to very heavy starting currents by applying directly the full voltage to a standing armature. In this connection may be mentioned another very common fault, which is found in starters for shunt motors, which consists in taking the connection from the last stop in the resistance. This results in the voltage applied to the shunt at the moment of switching on being lowered to the same extent as the voltage applied to the armature, with the result that to get the necessary starting torque the full-load current has to be much exceeded. The starting torque can be kept up by attaching the shunt wire to the first stop in the resistance. When the switch is in the "on" position the current for the shunt is required to flow back in the resistance, but as a general rule this is a matter of little importance. Table III. sets forth as far as possible the conclusions reached as to the causes of breakdowns. Constructional defects are responsible for 39.36 per cent of the total number of breakdowns. Almost half of the total failures were due to bad designs, and 7.4 per cent due to deterioration of insulation under normal conditions of work. Comparatively few of the failures were found in the mechanical portions of the machines. The great majority of the faults in design appear to be in the electrical portions of the machines, and for the most part are due to a lack of insulation, insufficient insulating ridges, and improper arrangements for supporting the conductors and their insulation. The writer is of the opinion that owing to the stress of competition many designers sacrifice, to a great extent, reliability to cheapness. In the case of small and medium size motors the tendency is to design machines for a higher rise of temperature than experience has shown to be compatible with the reasonable durability of the machine.

TABLE II.—Points of Origin of Breakdowns. The Percentages given show the Frequency with which the Various Parts caused Breakdowns.

	Per cent.
Mechanical portions:	
Shafts	0.78
Bearings	8.60
General	1.65—11.03
Brush-gear, leads and terminals:	
Mechanical	3.90
Insulation	2.35
Leads and terminals	2.35— 8.60
Field magnets:	
Failure of coil insulation	7.80
Breakage of wire	0.78— 8.58
Armatures:	
Core and slot insulation	12.50
End insulation (that is, separating bridges)	5.50—18.00
Coil insulation	11.70
Joints	7.00
Fasteners and binders	1.65
Binder insulation	7.80
Driving horns	1.65—47.80
Commutators:	
Insulation	9.40
Fastening and keying	5.50—14.90
Starters	4.70
Unknown	3.13
Various	1.56

TABLE III.—Causes to which the Failures were Due.

	Per cent.
Constructional:	
Bad design	18.36
Perishing of insulation	7.40
Bad workmanship	13.60—39.36
Conditional:	
Overloading	1.37
Over-rating	1.56
Unsuitable	0.78— 3.71
Maintenance:	
Dust and damp	7.40
Rough usage	1.56
Defective attention other than above	22.50—31.46
Accidental and unavoidable, with reasonable care in construction and working	7.05
Unknown	13.10
Caused by faults in accessories	5.48

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NIAGARA FALLS MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The fourth general meeting of the American Electrochemical Society was held at Niagara Falls, N. Y., September 17, 18 and 19. The meetings were held in the auditorium of the Cataract House, and were well attended. A session was held each morning, and the afternoons were devoted to excursions and visits to electrochemical plants and other points of interest. An interesting program was prepared, but many of the papers were of a highly scientific and theoretical character.

Electrolytic Copper Refining.

Dr. Wilder D. Bancroft presented a paper on electrolytic copper refining, in which he gave an account of a series of tests made in Cornell University to find the most economical conditions. The principal factors varied in these experiments were the temperature and the current density. Two sets of curves were plotted, one showing the relation between the cost to precipitate a ton of copper and the temperature of operation; the second set showing the relation between the cost to precipitate a ton of copper and the operating current density. From these curves it appears that a temperature of 70° is most satisfactory. Although the cost runs very high at this temperature for a current density of 1 ampere per sq. dm., it begins to drop off very rapidly as the current density increases, until it assumes a practically constant value at the higher current densities. Between 3.5 and 3.75 amperes per sq. dm. would be the best current density for obtaining economical results, for at this density no extra power would be required to heat the solution. Operating at this current density, and with covered tanks, in order to prevent the heavy radiation losses, the current alone would be sufficient to heat the electrolyte to over 80°. In order to secure a good circulation, essential for a good deposit with high current densities, the present method of pumping could be retained. If the gutters leading to and from the pump were properly insulated the solution would not drop below 70° before returning to the tanks. Moreover, running at this high current density, there would be a considerable saving in the first cost of the plant, inasmuch as fewer tanks are needed for the precipitation of a given amount of copper in a given time. The lower the cost of heating, the greater the advantage of a high temperature. The author sums up the results of the investigation by recommending, first, covered tank; second, a current density of 3.5 amperes per sq. dm.; third, a temperature of 70° C.

The paper of Dr. Bancroft was discussed by various copper refining engineers. Mr. Lawrence Addicks, of the Raritan Copper Works, said in a communicated discussion that electrolytic refining consists, from the standpoint of economy, in a very nice balance of a number of conditions, and that Dr. Bancroft has considered some, but has overlooked others, for instance, labor cost. The idea of covered tanks would be greeted with much hesitation by most refiners, for it is hard enough to get thorough inspection with an open tank. Every refinery is charged with interest and depreciation of plant, and these are not considered by Dr. Bancroft; he thinks that these charges would revolutionize Bancroft's cost tables. He sums up his criticism by saying that current density and temperature bear vital relations to the cost of refining, and that Dr. Bancroft has furnished valuable data concerning these items; for some refineries his conclusions may be correct, but not for all.

Mr. Benjamin Magnus, of the Anaconda works, gave as a result of his experience that the ampere-hour efficiency depends entirely on mechanical conditions. He seriously objects to covered plants and refers to the conditions used by the Anaconda refinery, where the current density is 10.5 ampere per sq. ft., the temperature of the electrolyte is 100° F. and the circulation of the electrolyte 3 gallons per minute. Under these conditions the chemical action in the tank is 1 per cent. greater than the electrolytic action, and the voltage per tank is 0.23 volt. In order to keep the solution constant day by day, the extra copper taken up by the solution is taken out by means of a tank with insoluble anodes. The cost of operating this tank in which the voltage is 2, is at least 8 times the cost of operating a regular depositing tank. If a temperature of 70° C. should be used and the current density be raised to 31.5 amperes per sq. ft., the excess chemical action would be so great that to free the electrolyte from copper by means of tanks with insoluble anodes, would cost so much that the saving of power due to warmer solutions would be more than offset.

Dr. Bancroft, in his reply, said that every refinery is now enabled to make the calculations of cost for its own case, taking their own figures for the other factors, purposely not taken into account in his paper. He considered that the difficulty of covered tanks was greatly overstated. If the covers are so arranged that they will swing or lift open easily, the only difference will be the slight extra time necessary to raise the covers. The fact that by means of covered tanks, nothing else being changed in the present arrangements, a saving of 30 per cent. in power may be accomplished, should certainly be of interest.

Efficiency of the Nickel-Plating Tank.

Prof. Oliver W. Brown presented a paper on this subject, which in the absence of the author was read by Mr. W. McA. Johnson. The make up of the present nickel-plating solution has been the result of the "cut-and-try" process, and few attempts have been made to give a good scientific explanation of why some solutions give better results than do others. Platers have also turned their attention mostly to the cathode and less to the anode, although a high current efficiency can only be attained if the anode corrodes at the same rate as the metal is deposited at the cathode. The nickel-plating cell is notably inefficient from this point of view; there is not only the resistance of the electrolyte to be overcome by the applied voltage, but an additional counter e.m.f., amounting in some cases to over two volts. To study the problem, the author has determined the signal potentials of anode and cathode separately, by means of a standard electrode.

His results show that electrolytic nickel anodes corrode very poorly as compared with cast nickel anodes; pure rolled anodes are no better than electrolytic. The cathode efficiency is affected to a marked degree by the anode efficiency. The satisfactory operation of a nickel-plating solution depends to a large extent on the character of the anode employed. The purest anode material is not the best; presence of copper is advantageous to a certain extent, and it is quite likely that certain other impurities which are usually present in cast nickel may be equally advantageous. The reason that cast nickel anodes show a superiority may be due to the impurities or to a different physical structure which gives rise to a great porosity and roughness of the surface, and thereby a greater actual surface area. The electroplater can obtain an efficiency of 90 per cent. or more if cast anodes are used, with an anode density of about 5 amperes per sq. ft.

In the discussion Mr. W. McA. Johnson thought that for the average plater the cost of standard electrodes and potentiometer would be too high. Prof. Burgess did not consider the cost to be excessive, and referred to the great convenience of using the Ostwald mercury standard electrode. There was also some discussion between Messrs. Gahl, Reed and Richards concerning over voltage.

President Richards presented a paper prepared by himself and Mr. W. S. Landis, entled

The Electrolysis of Water.

This is the second paper on the subject, the previous one having been presented at the last meeting of the society. The type of cell described in the first paper was very inconvenient, due to its great length, but by reducing the cross-section of the cell they have been able to obtain the desired high resistance with a much shorter tube. The cell now used consists of a capillary tube connecting the two vessels in which are placed the platinum electrodes. It was found that the size of the electrodes affected the readings very greatly. When these were small polarization took place rapidly. The area finally adopted was approximately twenty-five square centimeters to each electrode. Solutions of sulphuric acid of various concentrations were measured, the results of measurements being shown in tabular form and in curves. It was found that the current flow followed almost exactly Ohm's law up to three volts, beyond which point the readings were not carried. The resistance of the cell is very high, being about 284,000 ohms for a 1-10 per cent. solution. In measuring the current flow, polarization was corrected for by taking the readings at a definite time after closing the circuit. After obtaining the reading the circuit was then opened and the polarization current read after the same time had elapsed as in the first reading. This time was generally seven seconds, as that allowed the instruments to become steady. The sum of these two readings was then taken as the true value, as it was found that this method gave a constant flow, independent of the time elapsing after closing the circuit. Although no gas was given off at the electrodes during this work, gas will be given off at either pole if the electrode there be small, although there may be no gas appearing at the other. It is suggested that this method of measuring resistance might be useful in place of the Kohlrausch method.

SOME RECENT ELECTRICAL PATENTS

Constant Current Transformer.—Figs. 1 and 2 illustrate a transformer construction patented by Daniel O. Hull, the object of which is to transform from constant-potential to constant-current on the now familiar principle of increasing and decreasing magnetic leakage by the agency of the mechanical interactions between the primary and secondary windings, one winding being movably mounted. The principle is fundamentally the same as that of the well-known Thomson sliding-coil transformer, but in this case instead of varying the distance between the primary and secondary windings while the axes of the two remain identical, the axis of one winding is deflected out of or into parallelism with the axis of the other winding, after the manner of one of the well-known variable-reactance regulators. The inventor refers to the stationary coil, 5, as the primary and the coil, 6, mounted on a pivoted core, 4, as the secondary. The action will be obvious to those familiar with elementary electromagnetic principles. When the axes of the two coils are parallel the mutual induction is, of course, maximum, and the secondary e.m.f. is, therefore, maximum. While in a state of equilibrium any increase in the secondary current, due to short-circuiting some of the devices for example, will produce an increased repulsion between the two windings which overcomes the restraining influence of springs or other retractile devices and throws the axes of the two coils out of parallel to an extent depending upon the strength of the current, of course. When the axes are sufficiently far apart to reduce the mutual induction sufficiently to bring the secondary current back to normal value a state of equilibrium is again established and the core comes to a rest. The diagram, Fig. 2, illustrates the movable core deflected considerably from the position of maximum mutual induction. Patent 735,103.

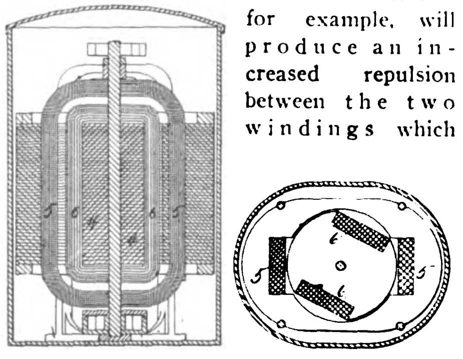

FIG. 1.—CONSTANT-CURRENT TRANSFORMER.—FIG. 2.

Motor Starting Switches.—Fig. 3 herewith illustrates diagrammatically an arrangement of switches and circuits patented by Allen H. Babcock for the purpose of providing certain features in the control of a direct-current motor during the operation of starting. The inventor provides the usual starting resistance, *L*, and switch, *I*, with a supplementary switch, *J*, for short-circuiting the starting resistance securely; also the usual form of over-load circuit-breaker, *K*. The unusual features of the arrangement are the connections of the field-magnet circuit and the composite switch, *M*, for controlling them. This switch consists of two blades, *D* and *E*, pivoted on the same spindle and provided with a spring, *N*, which tends to hold the two blades close together. The diagram shows all of the switches in the position for starting up.

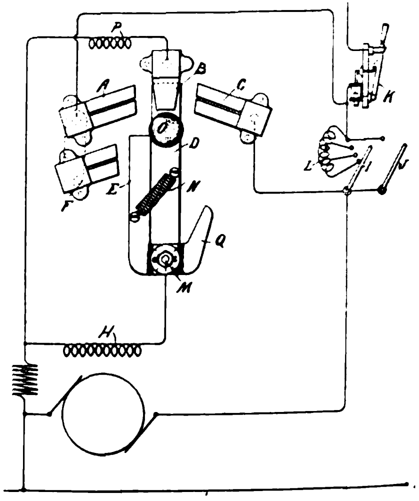

FIG. 3.—MOTOR-STARTING SWITCH.

The switch blades, *D* and *E*, are thrown to the left by means of the handle, *O*, thus connecting the shunt field circuit, *H*, directly across the supply mains through the cricuit-breaker, *K*. The starting resistance, *L*, is then cut out gradually in the usual manner, and finally short-circuited solidly by means of the switch, *J*. Then the switch lever, *D*, is thrown quickly to the right into the jaws, *C*. As the blade enters the jaws the lower part of it engages the heel, *Q*, of the blade, *E*, and pulls that blade out of the jaws, *F*. This obviously leaves the shunt-field circuit of the motor connected across the brushes of the machine, so that if the circuit-breaker, *K*, should open, the field circuit will not be opened, but will remain in shunt relation to the armature circuit of the motor. The central contact, *B*, of the switch, *M*, is provided for the purpose of discharging the field winding, *H*, through the resistance, *P*, in case it should become necessary for any reason to open the field circuit after it has once been excited. The inventor states that this arrangement is particularly applicable to starting rotary converters on the direct-current side. Patent No. 738,752.

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THE 24th CONVENTION OF THE ASSOCIATION OF EDISON ILLUMINATING COMPANIES.

The twenty-fourth convention of the Association of Edison Illuminating Companies was opened at the Hotel Frontenac, Thousand Islands, N. Y., on September 8, by its president, Mr. Louis A. Ferguson. As is well known, the Association sits in executive session at all times, and hence a complete report cannot be at present furnished. At the first session the reports of the lamp and meter committees and of the committee on National Code were received and discussed. A paper on "Overhead Pole Line Operation and Construction," by H. H. Manwaring and Mr. J. T. Hutchings, of Philadelphia, was then read.

In this paper the authors took up the necessary stages in the solution of the problem of current distribution. The old-time construction, it was found, was usually light and cheaply erected, and lack of proper maintenance increased the number of accidents, which, together with the unsightly appearance of the poles, strongly agitated public opinion against the entire construction. Various forms of wooden and metal poles were described, and also arrangement of circuits. The methods of fastening and dimensions of cross-arms were illustrated and described, and a part of the paper was given to a discussion of braces, pins, insulators, lightning arresters, fuse boxes, location and installation of transformers on the pole line, location and construction of main or trunk lines, grounding of secondaries, and complaints and rules. The paper advises that all secondary machines supplied by transformers should have the neutral of the three-wire system, or one wire of the two-wire system, grounded, the object being to prevent high-tension current from reaching the secondary wires. No wires smaller in size than No. 6 B. & S. gauge should be used for either primary or secondary work, and no fuse box or transformer should be placed upon a junction pole or arc lamp pole except where absolutely necessary. Poles should be spaced from 40 to 45 yards apart, depending upon circumstances, and in long lines every tenth pole should be guyed. Iron poles, generally speaking, should be avoided on account of the liability to shock to linemen on live wires. Poles of southern cedar lack mechanical strength, and pine poles are short-lived, chestnut poles being preferable to either.

A paper by L. L. Eldon, on the "Selection and Installation of High-Tension Switching Apparatus," discussed the development of alternating-current generating and transmitting apparatus, and emphasized the great consideration which is necessary in the designing of switchboard apparatus. The types of switches which have been developed were detailed, and several opinions cited as to the best method of locating the switchboard, the proper bus-bar arrangement and the distribution of generator switches. When considering the construction of a switchboard there are several points to be carefuly weighed before proceeding with the selection of the switching apparatus. The operation requirements should usually govern this selection, and on this point it is necessary to decide whether a considerable amount of the responsibility be allowed to rest with the operator, or whether a certain amount of special apparatus be installed with a view to rendering the entire installation automatic. The former course is without question the proper one to pursue, as the special apparatus devised to care for unusual occurrences is at times very erratic and unreliable in action, and under some conditions inoperative. When the reliability of the generating and transforming apparatus now furnished, and the freedom from burn-outs which it enjoys, are given full allowance, there is no good reason for complicating the switchboard to avoid an occasional emergency which may momentarily cause the use of the apparatus in excess of its rating. The emergencies that occur in a well-controlled station, which cannot be cared for safely and properly by a vigilant operator are few and far between, and generally speaking, fewer interruptions occur in stations where the switchboards are arranged with simplicity and reliable attendants are employed.

E. A. Leslie, in a paper on "The Development of Summer Lighting," gave an account of the result of extending the service of the Brooklyn Edison Company to Coney Island. The project for its extension at first met with opposition, but the result is indicated by the fact that the lighting load of Coney Island and other summer resorts to which the lines were subsequently extended has brought the load curves of the middle of the summer to an equality with that of the heaviest days of the winter. The most significant feature of the curve is that it shows that more machinery is required to handle the summer load than is required for the winter load.

E. W. Lloyd's paper on "Purchased Electric Power in Factories," reviewed the growth of electric power loads in central stations during the past ten years. There is scarcely a doubt, he said, but that the connected central station power loads in large cities will equal the connected light load at a very early date, as the removal of large isolated plants in office buildings and mercantile houses has increased the power loads of central stations greatly. The experience of one company demonstrates that in a great number of cases factory plant costs per kilowatt-hour were much in excess of what the central station is able to sell them current for at a profit. Low power rates are a detriment to central station business, as these rates are published by customers from place to place, and often business is lost because the prospective customer hears of an extremely low price in another city, where the local conditions, or more often the anxiety of the company to get a power load, prompts them to give a low rate without learning what it actually costs to operate the isolated plant. Before giving a prospective customer a price per kilowatt-hour, it is well to know what his factory plant costs are. In ascertaining these costs one will probably meet with difficulties. The manufacturer with engineering training, or having a mechanical or electrical engineer as manager, thinks he can generate power just as cheaply as we can sell it. We find, however, that a large portion of the customers with whom we ultimately do business, know little of their actual plant costs, and if their estimate of costs is taken, we would find a cost per kilowatt-hour with which it would be impossible for us to compete. A careful investigation of the plant will determine whether their figures are correct."

W. B. Thompson, of Detroit, presented a paper on "Commercial Experience with Nernst and Meridian Lamps," the discussion upon which was participated in by A. J. Wurtz, the manager of the Nernst Lamp Company, and others. Other papers presented were: "The Central Station and the Isolated Plant," by Douglas Burnett; "A Comparison of European and American Engineering Practice," by Charles Schwartz; "Notes on Commercial Features of European Lighting Practice," by A. Williams; "Depreciation in Electric Light Plants," by H. M. Edwards, and also a supplementary paper by H. A. Anthony; "Results Obtained with Steam Turbines in Milan," by Guido Semenza, and a paper on "Steam Turbines," by August Krusi. The report of the storage battery committee was received and discussed, some very interesting information as to the Edison battery being furnished. C. P. Steinmetz gave a valuable and interesting lecture on "Illumination," Thursday night. Following are the officers elected for the ensuing year: President, Mr. J. B. McCall, of Philadelphia; vice-president, Mr. C. C. Perry, of Indianapolis; secretary, Mr. W. S. Barstow, of Portland, Ore.; treasurer, Mr. Alex. Dow, of Detroit. Executive Committee—C. L. Edgar, Boston; Samuel Insull, Chicago; J. W. Lieb, Jr., New York; L. A. Ferguson, Chicago, and T. E. Murray, Brooklyn.

NOTES.

The Master Steam Boiler Makers Association will hold its annual convention in the Palmer House, Chicago, October 7, 8, 9 and 10, on which occasion it is expected that the largest number of superintendents, foremen, assistants and designers of boiler shops ever congregated together will be present.

The Johnstown (Pa.) Light, Heat and Power Company intends putting up a modern and first-class telephone exchange in conjunction with its lighting business. The exchange office will be located in the same building with the electric light offices. Mr. Aug. Weis is the superintendent of the company.

Thermostats on the Yaryan Hot Water Heating Systems.—Thermostats are to be placed on the premises of all customers of the Yaryan heating system at Evanston, Ill. It has been found in this plant, as in many others, that there is likely to be considerable waste of heat by customers where thermostats are not used to turn off and on the hot water as occasion requires. The compressed air for operating these thermostats, instead of being piped from the central station, as is usually the case where thermostats are employed in connection with a hot water or steam heating system, is to be supplied from storage air tanks located on the premises of each customer; this being done to avoid tearing up the streets to place compressed air pipes along the hot water mains. These tanks are to be of sufficient capacity to last through the season, and are to be changed each year. It is expected that a saving of 40 per cent. in fuel will be effected by the use of thermostat regulation, as against hand regulation by the customers; the customers being inclined to open or close doors and windows rather than turn the radiators off or on.

Steam Turbines for the Pennsylvania Terminal Station.—An order for three steam turbines of 7400 electrical horse-power each has been placed by the engineers and constructors for the Pennsylvania Railroad in connection with the New York Terminal equipment. These machines will form the initial installation in the new Long Island power house, on which construction is just beginning, and which will supply power for traction in the tunnels under the Hudson and East Rivers and the New York Terminal at Thirty-second Street and Seventh Avenue. The turbines will be of the Westinghouse, horizontal, short-barrelled type, mounted upon a single bed-plate, resulting in a particularly compact arrangement and great economy of floor space; they will each drive a 5500-kw., three-phase alternator, and the three generators will be operated in parallel; their overload capacity will be over 11,000 horse-power. Each turbine will be provided with a by-pass automatically controlled by the governor to accommodate abnormal fluctuations in load; this will also permit operation at full load non-condensing. The turbines will operate at 200 pounds steam pressure at the throttle, 28 inches vacuum and 175 degrees (Fah.) superheat. The generator will be connected to the turbine shaft through a flexible coupling, each section of the unit having two bearings, so as to avoid shaft stresses. The generators will deliver current directly to the distribution system at 11,000 volts, no step-up transformers being employed.

Electric Traction Experiments on Prussian Railways. —In the experiments which have just been commenced on the Spindlersfelde line in the outskirts of Berlin, it is not intended to attain very high speeds, but rather to demonstrate the practicability of the single-phase, alternating-current system, including a new motor designed by the Union Elektricitäts-Gesellschaft. This company, it will be remembered, supplied part of the electrical apparatus for the London Two-penny Tube in conjunction with the British Thomson Houston Company, and has made a specialty of electric traction. The Union Elektricitäts-Gesellschaft and the Allegemeine Elecktricitäts-Gesellschaft, as recently announced in these columns, have combined, forming one of the largest concerns in the field of electric industry. The motor in question, according to reports received from our European correspondent, seems to have all the best characteristics of the ordinary, direct-current railway motor, which has proved so successful all over the world. It is said to be capable of all necessary speed regulation without requiring expensive, cumbersome or uneconomical regulating devices. The line current is at a potential of 6000 volts, and is led directly to the motors without transformation.

Electricity on Tap from Space.—According to the daily press dispatches, F. X. Schoonmaker, of Chicago, who has been investigating A. G. Whitney's "theory" of getting electricity from the ether, talking of the results of his investigation, says: "There has been a great contention among scientists regarding the thickness of the atmosphere shrouding the earth. By many it was said to be 500 miles thick. At Pike's Peak it was believed to be fifty miles in thickness. Mr. Whitney stated that the shroud of atmosphere was not more than four miles thick at Pike's Peak; that I find to be correct. Mr. Whitney proposes to fire a cylinder into the air above Pike's Peak, and the cylinder will contain a magnet, a coil of strong copper wire, and a time clock. When the height of two miles is reached the clock will open the cylinder and the wire will begin falling, uncoiling as the magnet ascends, and finally the magnet will reach the ether and be held there while the end of the coil of wire touches the earth. It is possible to make connection with the simplest machinery. When the iron touches the ether it will become luminous and remain there. What we will want is a gun that will shoot four miles above the peak. The plan is entirely feasible. A practical demonstration will amaze the scientific world and give new life to industries that are languishing by reason of the great cost of motive power."

Isn't that beautiful? The momentum imparted by the cannon's charge to the magnet is to carry it on beyond the atmosphere, while the coil of wire is to discard its inertia automatically, and be drawn back to the earth. And it is stated that sane capitalists are financing Mr. Whitney's dream.

The International Conference on Wireless Telegraphy.—At the first meeting of this conference, which was held recently at Berlin, it was decided to keep the deliberations strictly private for some time so as to enable the representatives of the various countries to present their reports at home. It appears now, however, from a recent official report by the *Kölnische Zeitung* that the following decisions were arrived at:

Shore stations will have to receive and to transmit in their communications with ships any telegrams without discrimination as to system. In order to facilitate wireless communication between vessels and shore stations, technical particulars will have to be made public. The stations will have to transmit preferentially telegrams relative to ship disasters and applications for help from ships. The States concerned will further have to establish transmission rates, to be based on the existing rates (as charged for the transmission by wire overland) with a special additional fee for transmissions by wireless telegraphy; telegrams are to be charged for according to the number of words they contain. As regards telegrams transmitted from territorial stations, the fee will have to be paid to the latter, the amount being dependent on the power involved. Telegrams transmitted on board ship are to be prepaid to the ship station, the rate to be determined by the nation to which the ship in question belongs. It was also agreed that wireless telegraph service must be regulated so that the various stations will interfere with one another to the least possible degree.

Although this provisional conference consisted only of representatives of the most important States, the remaining nations will by no means be excluded from further definite deliberations. As regards participation in the decisions of the convention just concluded, any State that wishes to do so and to accept the conditions established in the definite conference to be held later will be allowed to join it. These regulations were signed by all the participants excepting England and Italy, Italy having concluded a fourteen years' contract with Marconi. The English are going to submit to their government the deliberations of the preliminary conference, although existing regulations of these matters in England would entail certain reservations.

The New York State Street Railway Association.—The twenty-first annual meeting of the New York State Street Railway Association will be held at the Yates Hotel, Syracuse, Tuesday and Wednesday, October 6 and 7, 1903. This meeting has been called a month later than usual because the American Street Railway Association held its convention this year during the early part of September, which is the time when the New York Association usually convenes. An unusually interesting meeting is anticipated.

Numerous papers upon important street railway subjects will be presented and topics of general interest and profit to street railway men will be thoroughly discussed. In addition to the interesting and profitable features of the meeting a splendid program of entertainment has been arranged by the local committee. The Association is very desirous to have a large attendance, and wishes to have it plainly understood that supply men are particularly invited, and will be tendered a cordial welcome.

Among topics for papers and discussion are these: "Care of Dynamos"; "Points on Overhead Construction"; "Long-Distance Power Transmission"; "The Inspection and Care of Brakes"; "Signal Systems for Single-Track Roads"; "Effect of Interurban Service on Small Towns"; "Track Bonding"; "Rotary Transformers"; "The Modern Power House"; "Power Brakes for Electric Cars"; "Electrolysis"; "Care and Inspection of Motors"; "Economical Maintenance of Boiler Room"; "Hints on Making Small Electric Railroads Profitable"; "Store-Room Accounting and the Distribution of Supplies"; "Economical Production of Steam"; "Electric Lighting by Street Railways"; "Repair Shop Methods" (Allotted); "Track Drainage—Interurban Roads"; "Steam Turbines"; "Single and Double Trucks—Their Advantages and Disadvantages"; "The Sub-Station."

In addition to the papers allotted and selected from above list of topics, there will be an allotment of sub-topics and ensuing general discussion upon the following practical subjects suggested by H. H. Vreeland: "Interurban Service" (divided into three heads), (a) Standard Equipment, (b) Car Despatching, (c) Standard Methods of Fare Collection and Ticket Taking; and "Extra Freight and Baggage Service on Interurban Lines" (divided into three heads), (a) Traffic Arrangements with Steam Roads and Boats, (b) Traffic Arrangements with Other Interurban Lines (c) Development of Freight and Express Service.

In pursuance of the suggestion of the Board of Railroad Commissioners of the State of New York, there will be a general discussion of "The Advantages and Disadvantages of Oil Tail Lights for Interurban Cars," and "Street Car Controllers—Their Proper and Improper Operation."

Water Power Development on the Chicago Drainage Canal.—Definite steps have been taken toward the utilization of the water power of the Chicago main drainage canal, and the construction of the works necessary for water-power development will be shortly put in hand. The development is to be at Lockport only; although it had been reported that it included Joliet also. The Sanitary District has, however, not yet secured all the property at Joliet necessary for the carrying out of the maximum possibilities of the development. Bids are being invited for the construction of the head-race and tail-race. The plans proposed by the chief engineer and adopted by the Board of Trustees provide for the extending of the main channel from the present controlling works south about 10,500 ft. to the location of the power house. This extension or head-race will have a minimum width of 160 ft., and a grade on the bottom of 1 in 20,000, in continuation of the grade of the channel north of the controlling works. As the natural surface of the ground varies from 15 to 30 ft. below Chicago datum it is necessary to impound the water of the head-race. This is to be accomplished by constructing on the east side a concrete retaining wall of natural cement with a Portland cement facing, reinforced by a rock fill 44 ft. wide on top, with a 1 to 1 slope on the easterly side; on the west side will be a levee of rock with an earth core, but where the height demands it this core wall will be of concrete. The tail-race is to be a channel of the same dimensions as the completed channel, and is to extend about 7,000 ft. to a junction with the Desplaines River. The river channel is to be deepened for a width of 160 ft. to afford a minimum depth of 10 ft. through to the upper basin at Joliet. At the east of the power-house site a lock 22 x 130 ft. is to be constructed to enable boats to pass from the Illinois & Michigan Canal into the head-race. This is provided for the reason that that part of the Illinois & Michigan Canal between Joliet and Chicago will be abandoned upon the completion of the water-power development. A bear-trap dam for the regulation of the flow in the channel, and for the removal of ice and debris, is also to be constructed between the power house and the lock. The power house is to be constructed of concrete and brick. It is to have ten turbine chambers; seven for power units and three for exciter units. The power units are each designed to pass 100,000 cu. ft. per minute at 0.8 discharge. They are to consist of turbines on horizontal axes, capable of generating 6500 h.p. with gate fully open under a 34-ft. head, and at 150 r.p.m. Each power unit is to drive one three-phase, 2200-volt generator of 3750 kw. The number of cycles has not yet been determined. As the ultimate discharge of the canal will be 600,000 cu. ft. per minute, it will be seen that six units at 0.8 discharge will utilize the whole flow. The seventh is added so that one may be held in reserve to take the place of any unit laid up for repairs. Two of the exciter units are sufficient to furnish the proper excitation. Each unit is to be provided with a ground and electric speed controller, and the generator room is to be provided with an electric traveling crane of 50 tons capacity.

The Illinois State Electric Association.—The annual meeting of the Illinois State Electric Association this year took the form of a pleasure trip from St. Louis to Beardstown, Ill., on the Fish Commission steamer *Illinois*, the use of which was granted the Association for two days. The Association met at the Southern Hotel, St. Louis, on the morning of September 19; a visit to the World's Fair grounds, at St. Louis, occupied the morning. In the afternoon the party took the steamer for Alton, which was reached at 7 o'clock, after a short stop at the works of the St. Louis Car Company, at Baden. At Alton, President J. F. Porter took the visitors in a special car to visit the plant of the Alton Railway, Gas & Electric Company, and later entertained them with a theatre party. The next day the trip up the river was resumed, and the delegates left the steamer in the evening at Meredotia and at Beardstown. The only formal meeting held was the one at which the old officers were reelected, as follows: W. E. McCullough, Beardstown Electric Light & Power Company, president; John W. Glidden, of De Kalb, first vice-president; R. L. Allen, Economy Light & Power Company, Joliet, Ill., second vice-president; C. L. Gerould, Galesburg Gas & Electric Company, third vice-president; D. Davis, Litchfield Electric Light & Power Company, treasurer; H. E. Chubbuck, Citizens' Lighting Company, LaSalle, Ill., secretary; and W. B. McKinley, Urbana & Champaign Railway, Gas & Electric Company; J. N. C. Shumway, Taylorville Electric Company; Frank J. Baker, North Shore Electric Company, Waukegan; C. E. Hay, and S. S. Davis, People's Power Company, Moline, Ill., executive committee. No papers were presented, but considerable technical discussion was carried on between the members informally. The place of the next meeting was left to the executive committee, with some sentiment in favor of holding it at St. Louis at the time of the Exposition. The Association now has over 90 companies on its membership list.

The following delegates were in attendance at this meeting: J. F. Porter, Alton Railway, Gas & Electric Company; W. E. McCullough, Beardstown Electric Light & Power Company; F. M. Sinsabaugh, Carrollton Electric Light & Power Company; W. B. McKinley, Urbana & Champaign Gas & Electric Company; William A. Fox, Chicago Edison Company; Frank J. Baker, North Shore Electric Company, Waukegan; W. A. Bixby, Decatur Gas & Electric Company; Charles A. Vallette, Edwardsville Light & Power Company; H. A. Foster, Fairbury Electric Light & Power Company; S. L. Nelson, Galesburg Gas & Electric Company; J. J. Frey, Hillsboro Electric Light & Power Company; J. P. Brown, Hillsboro Electric Light & Power Company; H. E. Chubbuck, Citizens' Lighting Company, LaSalle; S. P. Bartlett, Citizens' Lighting Company; F. W. Bedard, Citizens' Lighting Company; D. Davis, Litchfield Electric Light & Power Company; S. S. Davis, People's Power Company, Moline; C. E. Sharpe, People's Power Company; Robert Ferris, Edison Illuminating Company, Monmouth; W. J. Ferris, Edison Illuminating Company; W. C. Alexander, Murphysboro Water Works, Electricity & Gas Light Company; E. S. Hughes, Olney Electric Light & Power Company; R. H. Abbott, Petersburg Electric Light Plant; J. W. Race, Quincy Gas & Electric Company; W. A. Martin, Qunicy Gas & Electric Company; A. V. Schroeder, Springfield Electric Light & Power Company; E. D. Stiles, Streator Gas & Light Company; J. N. C. Schumway, Taylorville Electric Company; H. J. Frith, Watseka Electric Light & Power Company; Nat Cohen, Citizens' Lighting Company, LaSalle; Geo. D. Rosenthal, Jerseyville Electric Light, Gas & Power Company; C. L. Gerould, Galesburg Gas & Electric Company; W. E. Keily, *Western Electrician*; J. R. Cravath, American Electrician.

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CONTENTS.

Power Plant of the Southern Pacific Terminal Company at Galveston, Texas, by C. W. Whitney 475
Generating Equipment for Isolated Plants, by Paul C. Percy 480
A Simple Alternating-Current Booster, by F. B. O'Hanlon 481
The Production and Distribution of Alternating Current for Large City Street Railway Systems, by Richard McCulloch 484
Telephone Engineering, by F. J. Dommerque 488
Power and Lighting Plant of the Grand Union Tea Company at Brooklyn, N. Y. .. 491
International Association of Municipal Electricians 496
Convention of the American Street Railway Association 497
Abstracts from Foreign Contemporaries 501
Niagara Falls Meeting of the American Electrochemical Society 503
Some Recent Electrical Patents 504
24th Convention of the Association of Edison Illuminating Companies 505
Notes 506
Editorial 508
Construction of a Direct-Current Enclosed-Arc Lamp 510
Rheostats for Dynamo Load Tests 512
Indicator Diagrams, by Chas. L. Hubbard .. 513
Two-Wire Intercommunicating Telephone Systems, by H. S. Webb 515
Parallel Operation of Alternators, by F. Hardie Jeannin 517
Lessons in Practical Electricity 518
Letters on Practical Subjects 520
Queries and Answers 521
Ruger Gas Engine 522
A Small Residential Plant 522
New Apparatus and Appliances 523
New Books 525
Current Densities in Standard Wires 526
American Street Railway Convention Notes.. 526
Personal .... Adv. 61
Trade Publications .... Adv. 61
Business News .... Adv. 61

Isolated Plant Generating Equipment.

The example of Banquo's persistent ghost is followed by many factors in engineering methods, among them the threadbare question of direct *vs.* alternating-current distribution, which declines to "down" or be otherwise disposed of, except when a plant involves power transmission over long distances. One would suppose that the legitimate field of each class of apparatus had been so thoroughly demonstrated by this time that there would be no room for discussion except in the case of plants coming partly within both of the recognized fields. The fact remains, however, that alternating-current apparatus is daily advocated by one set of partisans for factory and shop equipment, and direct-current systems continue to be just as energetically recommended for scattered central station systems by those holding anti-alternating views. The remarks on another page concerning the choice between direct and alternating current for isolated plants, therefore, may not be quite superfluous, and certainly the opinion expressed in the article referred to is entirely logical.

It is unnecessary to reiterate what has been so often said before concerning the proper field for alternating-current equipment; moreover, no one professionally interested in the subject needs any information concerning it. But it really would be interesting to look over a list of the engineering reasons for the use of induction motors to drive grain elevators, for example. We are, of course, familiar with the old story about "grindstone simplicity," in which there is an appreciable element of common sense; but everyone is also familiar with the reliability of a modern direct-current motor and the disadvantages of the induction motor; also the nuisance of operating rotary converters in case any direct-current service is required, not to mention the first cost of these latter amiable machines.

Concerning the practice, referred to in the article mentioned above, of limiting the number of isolated plant generating units to two as the minimum and four as the maximum, this would seem to be somewhat arbitrary upon first consideration, and is undoubtedly intended to apply to plants of ordinary everyday magnitude, such as those in office buildings, hotels, and single-building factories. Within the limits of this class of plant the rule of "no less than two nor more than four" may apply very well. A 2000-kw. isolated plant is well up toward the top of the list, as to output, and such a plant could be very economically operated with three or even four units; one large enough to require more than four units, on engineering grounds, would serve a pretty large establishment.

Belted vs. Direct-Connected Units.

In view of the almost universal practice of putting in direct-connected generators whenever the higher cost is allowed, the preference for belted units, expressed in the article on generating units for isolated plants which is printed on another page, may seem out of date, and certainly sounds prejudiced as it is stated. The question is not one merely of flexibility in emergencies and the space occupied by the plant, although these considerations are weighty. Belted generators, as a rule, operate at about double the speed of direct-driven machines, in ordinary sizes; for the same reason that speeds of 1800 to 2400 r.p.m. in small motors have been practically superseded by speeds of 1000 to 1400 r.p.m. in the same sizes, generator speeds of 200 to 400 r.p.m. are much preferable to speeds of 500 to 900 for the same range of outputs, even if the two classes of machines be designed for identical peripheral velocities in identical sizes. Moreover, belts are of themselves a good deal of a nuisance; besides entailing some power loss and a large amount of attention they render it much more difficult to get quickly from one part of the generator room to another.

On the other hand, direct-connected generators are slightly less efficient than belted machines, although the saving in belt loss and maintenance will usually offset this. But the chief disadvantage lies in the rigid connection between the source of power and the load; every violent fluctuation in load racks and may strain both the engine and the generator, whereas the slippage of an intervening belt takes off a large part of the shock. Again, a direct-connected generator of given output is far heavier than a belted machine of the same capacity, so that in the event of having to dismantle the machine for repairs the job is much more formidable; the machine is also less accessible for inspection and dismantling, being hemmed in on one side by the engine structure.

The foregoing points are only a few of the many that should be considered in deciding between belted and direct-connected units when the available space is sufficient for belting; where this is not true, discussion is useless, of course. Assuming the engine and generator to be amply capable of withstanding the maximum stresses that may be expected in practice, we should, as a general proposition, prefer direct-connected units on account of their compactness and the elimination of belt annoyances; but with engines and generators built on an ultra-economical basis, "to sell" only, we should prefer to struggle with belts.

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The Generation and Distribution of Power for Street Railway Systems.

The development of the large electric systems now characteristic of the most populous and prosperous sections of the country has added another problem in high-grade engineering to the list—the arrangement of large main and sub-stations, which, of course, involves also the choice of equipment. It appears to have been very definitely determined that the generators of interurban plants should be alternators, on account of the facility of transformation and the resulting economy in transmission afforded by alternating currents; the rotary converter sub-station has also come to be a standard feature of such plants, pending the development of a practical alternating-current car motor. But there are many points concerning the choice, installation and operation of this and allied apparatus upon which competent advice is warmly welcome; hence the enthusiastic reception, at the recent Street Railway Convention, of Mr. McCulloch's paper, which we print in abstract elsewhere in this issue. Some of the sections of the paper are disappointingly brief and summary, but it is, on the whole, a most excellent résumé of modern practice in plants of the class discussed.

The choice between direct and alternating-current generation for large city railway systems is by no means logically in favor of alternating currents under ordinary conditions. As pointed out by Mr. McCulloch with rare freedom from bigotry, the direct-current system is preferable on the scores of greater simplicity and reliability, operating costs being equal, and it is a moot question whether the alternating-current system is ever as economical as its rival for strictly urban service. It is true that the great Metropolitan system in this city was changed over, on advice of highly competent engineers, to a primary alternating system with the necessary converter sub-stations, but the wisdom of the plan has not yet been made clear by the publication of operating records. With the two magnificent water fronts available here, it would seem that a plurality of direct-current generating stations would have shown much better economy than the existing plant of main and sub-stations. A rotary converter station of respectable size requires a larger staff of high-grade men than a generating station of the same output, and in a plant of the magnitude of this one each of the several generating stations would be of sufficient size to operate with the maximum economy obtainable in a single mammoth station. It would be of much interest if a comparison of station operating expenses could be drawn between the New York Metropolitan and St. Louis direct-current system, with proper allowances for differences in specific costs.

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Railway Motor Construction.

Some timely and deserved comments on modern railway motor construction formed part of an excellent paper read by Mr. E. W. Olds at the Street Railway Convention. The author pointed out that certain features of motor construction have not shown the same degree of progress that characterizes other features of the machine and other parts of a railway system. Unless the author has been erroneously reported, however, his remarks concerning commutator brush contact and the insulation of wires bear about the same relation to the remainder of his paper that the merits of the motor features which he criticises correctly do to those of the more improved parts of the equipment. The demand for better conductivity in the electrical path between the brush-holders and the armature winding is certainly warranted by existing practice, but the statement that the deterioration of the commutator surface causes the overheating and ultimate burning out of the armature and field windings is puzzling, to say the least of it. And the author's comment concerning the inadequacy of the cotton insulation on magnet wire does not seem quite fair to the cotton. It is substantially a complaint that the insulation will not stand a sufficiently high temperature to enable one to abuse the motor.

Both cotton and silk insulation, especially the former, will withstand pretty high temperatures for a reasonable length of time before carbonizing. There appears to be no good reason why railway or other motors should be operated at carbonizing temperatures, and when they are, the insulation on the magnet wire is not the only part that suffers. Since silk yarn is equal in mechanical and insulating qualities to cotton yarn of about double the thickness, it would seem that the use of silk instead of cotton insulation on magnet wire might prove worth while in the case of motors of this class, which must be worked to the utmost on account of space and weight limitations. This would, of course, allow a slight increase in copper cross-section under given conditions, and reduce the I^2R loss. Whether the reduction in heating, and therefore vulnerability, would be sufficient to justify the extra expense, we have never undertaken to determine, nor are we aware that anyone else has.

The value of "pigtails" in relieving the brush fingers and springs from electrical duty is so well known and has been so conclusively demonstrated in practice that it is surprising to learn from the paper under discussion that some users report the "pigtail" to be of no benefit. Unless the brush-feeding fingers are more massive than any we have ever seen and the springs are perfectly insulated from the fingers, the use of "pigtails" is absolutely imperative where ordinary box-type brush-holders are used. When reaction brushes and holders are used this is not always true, the brush being pressed firmly against the plate regardless of the direction of the commutator rotation. We happen to know, however, of several cases where the operation of even the reaction type of holder was conspicuously improved by adding "pig-tails," and some manufacturers of stationary motors using this form of holder deem it wise to provide them, or their equivalent in flexible flat straps of copper on all their holders.

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Once More the Revolutionizer.

The fallacy of the Newtonian law of gravitation is to be made clear at an early date—again. At least, that is what the waiting public is given to understand by a representative of the latest of the long line of upsetters of accepted scientific laws, the representative having "looked into" the plan and found it perfectly feasible. The gifted originator of the scheme several months ago announced his intention to shoot a huge magnet up beyond the reach of the earth's attraction, leaving a trail of wire behind by means of which we are to draw unlimited electricity from the ether, but no one imagined that financial backing would ever be found for so wild an enterprise. According to the aforesaid representative, the "angel" or "angels" actually developed and the project is to be pushed. Just why a magnet will hang up in the ether any better than anything else is not explained, but for that matter, none of the other features of the weird theory have been explained. Meanwhile, inventors with real merit, and originators of legitimate industrial schemes seek financial support in vain.

CONSTRUCTION OF A DIRECT-CURRENT ENCLOSED-ARC LAMP.

The enclosed-arc lamp shown by the accompanying sketches is intended to be made without castings, so that anyone having a lathe and other small tools and a fair knowledge of electrical apparatus will be able to make a reliable arc lamp. This lamp is designed for a 110-volt direct-current circuit, and for indoor service. Figs. 1 and 2 show front and side elevations; the dash-pot is left off in the front elevation, so as to show how the clutch-rod is fastened to the armature. The top, casing and side rods are insulated, so that the lamp is as safe to handle as any of the commercially built lamps.

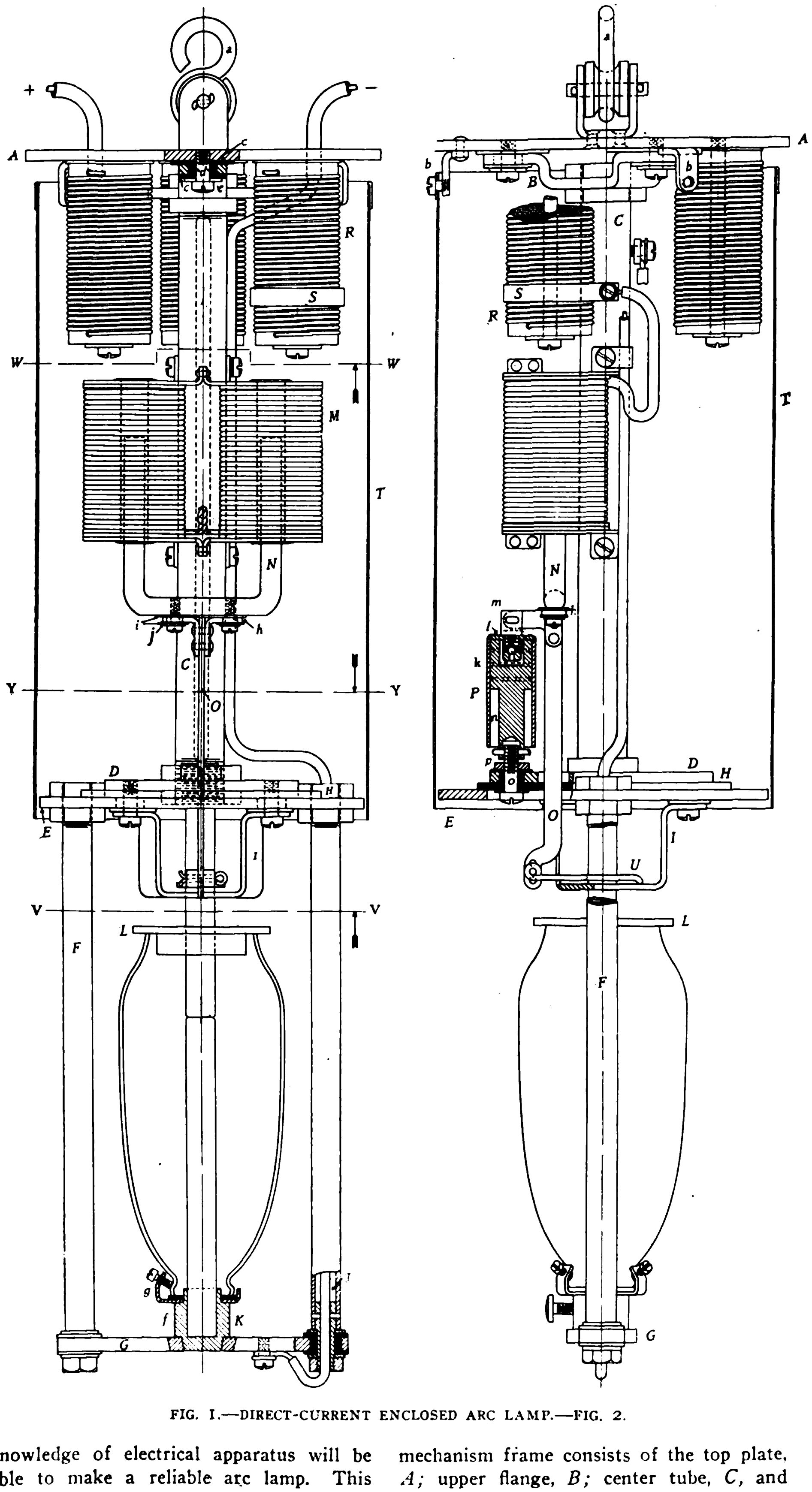

FIG. 1.—DIRECT-CURRENT ENCLOSED ARC LAMP.—FIG. 2.

The lamp consists of two main parts—the mechanism frame and lower frame; the mechanism frame consists of the top plate, *A;* upper flange, *B;* center tube, *C,* and lower flange, *D;* the lower frame consists of the top, *E;* side rods, *F.F,* and lower yoke, *G.* The top plate, *A,* is made of iron or brass 3-16 in. thick x 6½ ins. diameter, and on top of it is riveted a strip of ⅛-in. iron or brass bent as shown to fit the porcelain hanger knob; no dimensions are given, as the size and shape of this piece should be governed by the kind of porcelain knob that can be bought in the vicinity where the lamp is being made. A piece of ¼-in. iron wire should be bent as shown to form the hook, *a.* On the bottom of the plate, *A,* are riveted three lugs, *b, b, b,* tapped for No. 10 machine screws, to hold the casing; the lugs are made of ⅛-in. iron or brass. The resistance is also screwed to the bottom of this plate, the description of which will be given later. The upper flange, *B,* is made of iron or brass 3-16-in. thick, bent as shown in Figs. 1, 2 and 3, and fastened to *A* by three No. 14 machine screws, which are insulated from *B* by 1-16-in. mica washers, *c, c,* above and below, and a mica bushing, *d,* ½ in. outside diameter x 3-16 in. long; a brass washer, *e,* 1-16 in. thick x 11-16 in. diameter goes under each screw-head. Fig. 3 shows a cross-section at *W, W* (Fig. 1), looking in the direction of the arrow; this view shows the shape of *B,* also the arrangement of parts on the bottom of *A.*

The center tube, *C,* is made of brass tubing ⅝ in. inside diameter x ⅞ in. outside diameter x 11¼ ins. long. It is threaded at both ends with ⅞-in.-20 threads ¾ in. long. A slot ¼ in. wide is cut from thread to thread for the screw of the upper carbon holder. There are also four holes tapped for No. 10 machine screws to hold the magnet spools; the lower two holes are 4¾ ins. from the bottom of the tube, and the other two are drilled to match the spools. The tube is fastened to the plate, *B,* by two hexagonal nuts ¼ in. thick x 1¼ ins. across. The lower flange, *D,* is fastened in the same way; this flange is made of iron or brass 3-16 in. thick and shaped as shown in Fig. 4, which is a cross-section taken on the line *Y, Y,* Fig. 1, looking in the direction of the arrow. This view also shows the shape of the installation, *H,* which insulates the mechanism frame from the lower frame; it is made of horn fibre ⅛ in. thick x 4½ ins. diameter. The top, *E,* of the lower frame is made of iron or brass 3-16 in. thick x 5⅞ ins. diameter; two 17-32-in. holes are drilled 4½ ins. apart for the side rods in the position shown in Fig. 5, which is a cross-section taken on the line *V, V,* Fig. 1, looking in the direction of the arrow; the center of *E* is cut out, as shown in Fig. 5. The lower and mechanism frames are fastened together by three No. 14 machine screws and insulated from each other by mica washers, *H,* 1-16 in. thick x ⅞ in. diameter, and the bushing ½ in. outside diameter x 3-16 in. long; these screws also support the trip platform, *I,* which is made of iron or brass 3-32 in. thick. The shape and size can be easily seen from the three views, Figs. 1, 2 and 5.

The side rods, *F, F,* are made of ¼ in. iron gas pipe 9 13-16 ins. long; they are threaded ¾ in. at the top ends for two ¼-in. standard lock nuts, which can be bought at any hardware or machinists' supply store. The bottoms are fitted with iron plugs, *J,* pinned in with ⅛-in. iron pins; in one plug is a 3-16-in. hole for the negative wire. The plugs on the lower ends are threaded for a 5-16-in. standard nut. The two side rods are connected together at the bottom by the yoke, *G,* which is made of iron or brass ¼ in. thick x 5 5-16 ins. long; the ends are rounded to a 13-32-in. radius and the center to a ⅝-in. radius; the ends have 9-16-in. holes 4½ ins. apart for the mica bushings, which, with two mica washers 1-16 in. thick x 13-16 in. outside diameter, insulate the yoke, *G,* from the side rods. In the center of *G* is a tapered hole for the inner globe and lower carbon holder, *K,* ¾ in. diameter at the top and 11-16 in. at the bottom. The negative wire is connected to *G* with a No. 14 machine screw, as shown.

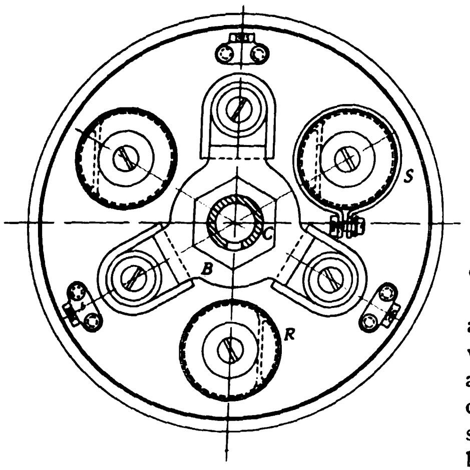

FIG. 3.—SECTION AT W, W.

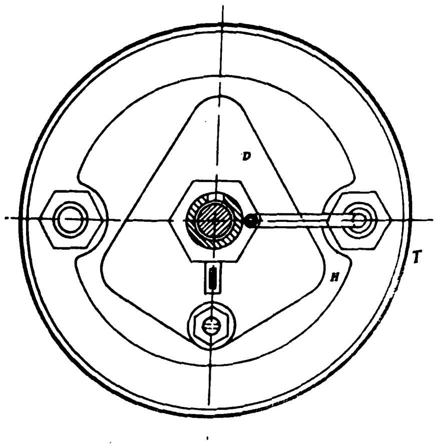

FIG. 4.—SECTION AT Y, Y.

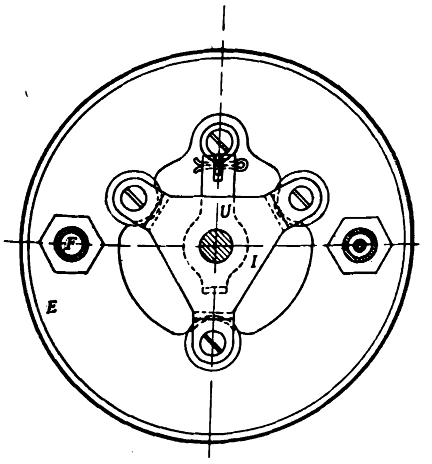

FIG. 5.—SECTION AT V, V.

The inner globe and lower carbon holder, *K,* is made of brass, the lower part, *f,* 1 in. diameter x 1⅛ ins. long turned down on one end to fit the taper in *G,* and at the other end to receive the piece, *g,* of sheet brass 1-16 in. thick, bent up as shown, with three short lugs for guides for the globe, and three long ones with No. 6 machine screws to hold the globe on. Under the globe is an asbestos washer 1-16 in. thick x 1¼ ins. outside diameter with a ⅝-in. hole; the piece, *f,* is drilled 0.525 in. diameter x ⅞ in. deep for the lower carbon, which is clamped by a No. 14 machine screw with a thumb-screw head.

The inner globe cap, *L,* is made of brass as shown in detail by Fig. 6. The joints will have to be made as nearly air-tight as possible by good machine work, as the cap gets too hot to permit the use of solder in fitting it up. This cap can also be made with only the top plate, with an edge turned down to center it, but the life of the carbons will be much longer with the cap shown.

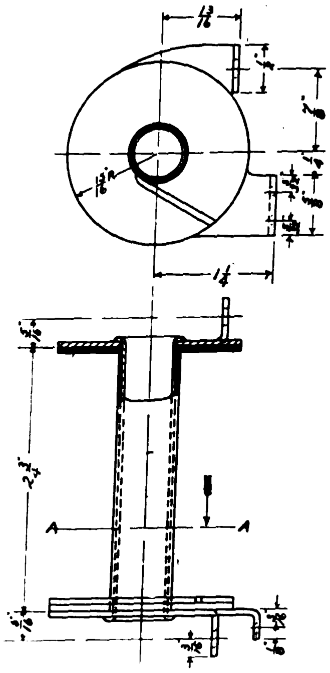

FIG. 7.—DETAIL OF MAGNET SPOOL.

The mechanism of the lamp consists o the magnet spools, *M, M,* armature, *N,* clutch-rod, *O,* dash-pot, *P,* and clutch, *U.* Fig. 7 shows the magnet spool in detail; the heads are made of brass 1-16 in. thick, having ears bent up to fasten on to the tube, *C,* also ears to fasten spools together after winding. The center tube is made of brass ½ in. inside x 9-16 in. outside x 3 1-16 ins. long. The winding is insulated from the spool at the top by a 1-16-in. cardboard washer 1⅞ ins. diameter, and at the bottom by the same kind of washer; but there is also a split washer the same size as the other, used for bringing out the inside lead. The center tube can be insulated by wrapping about three layers of paper around the tube; a layer of cotton cloth soaked in linseed oil would make the insulation a great deal better, but it should be well dried before using. After the washer and heads are put on the tube, the ends should be spun over so as to give the spool the dimensions shown.

The armature, *N,* is made of soft iron ⅜ in. diameter x 8½ ins. long, bent to the shape shown, 2½ ins. between centers. The bottom is flattened off so as to fasten the clutch-rod to it. The clutch-rod, *O,* is made of 3-32-in. sheet brass, cut to the shape shown and riveted to the pieces, *h, h,* which in turn are fastened to the armature by two No. 8 machine screws; these are insulated by the mica washers, *i,* and mica bushing, *j,* so that the clutch and dash-pot will not carry any current. At the lower end of the clutch-rod there are three holes for adjustment.

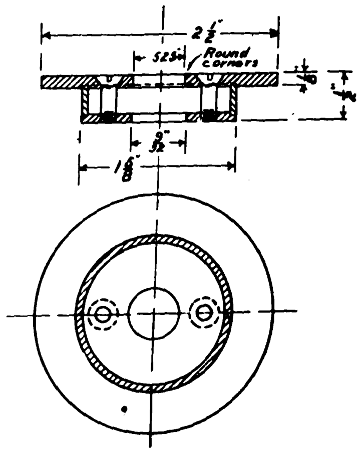

FIG. 6.—INNER GLOBE CAP DETAIL.

The dash-pot, *P,* is to keep the lamp from "jumping." The shell, *k,* is made of brass tube ¾ in. thick x ⅞ in. outside x 2 1-16 ins. long, and is spun over the piece, *l,* which has a seat for the ⅛-in. phosphor bronze ball valve, which is held in place by the support, *m,* through which is drilled a 1-16-in. hole to let the air out. The whole is supported by a cotter pin from the clutch-rod. The plunger, *n,* is made of ¾-in. brass rod 2⅛ ins. long, turned down at one end to 7-16 in. diameter; at the other end it is left full size, and must be a good fit in the shell. The three grooves shown help to make it act slower. In the bottom is drilled a hole 5-16 in. diameter for the No. 10 machine screw, which in turn is drilled for a cotter pin, by which the plunger is held. The screw, *o,* is insulated from the flange, *D,* as shown, and held by the hexagonal nut, *p,* which is made of ⅛-in. brass.

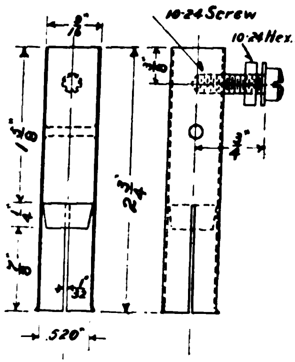

FIG. 8.—DETAIL OF UPPER CARBON HOLDER.

The clutch, *U,* is made of 3-32-in. brass, cut and bent to the shape shown in Figs. 1 and 5, and in the center has a reamed hole 0.532 in. diameter, with both edges well rounded.

Fig. 8 shows the upper carbon holder, which is made of brass. The lower end, after being split in four pieces, will be pressed in to fit the smallest carbon, and make a good contact.

The resistance, *R,* consists of three spools fastened to the top plate, *A,* by three No. 14 machine screws 3½ ins. long. The spools are turned out of soapstone 2 ins. diameter x 3¼ ins. long, with grooves 1-16 in. diameter and 3-32 in. between centers. The ends of the wire are fastened by putting them through the holes drilled in the edges of the spools as shown. They are wound with 0.049-in. high-resistance wire, which can be bought at any large electrical supply house. It will take about 50 ft. The ends must be left long enough in each case to reach to the next spool; the end of the last spool connected is left open, as shown in the diagram of connections, Fig. 9, and connection is made by means of an adjuster, *S,* which is connected to the magnet spool with a flexible cable somewhat similar in character to a flexible lamp cord. The adjuster, *S,* is made of brass 1-16 in. thick x 5-16 in. wide and clamped with a No. 6 machine screw and nut. The voltage of the arc is regulated by sliding this adjuster up and down. The magnet spools are wound with No. 14 double cotton-covered wire; there should be between 280 and 290 turns on each spool, with a loop at 245 turns; for 5-ampere adjustment the wires from the resistance and upper carbon holder are connected to the 245th turn; for the 4.5-ampere adjustment they are connected to the end turns.

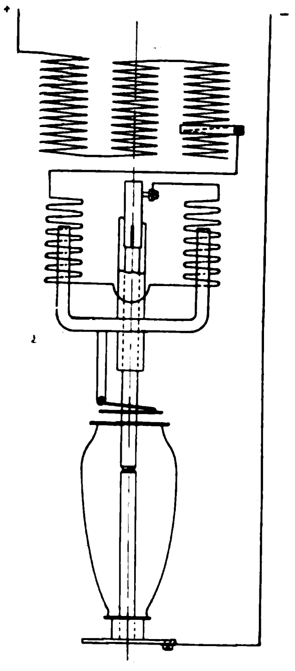

FIG. 9.—DIAGRAM OF CONNECTIONS.

The connection from the spool to the upper carbon holder must be flexible and well insulated, so as not to short-circuit any part of the lamp. If a well-insulated flexible cable is not available, get some glass beads and string them in the wire; they make a very good covering, and will not burn.

The negative wire must be about No. 11 or 12 copper wire, with any good fire-proof covering; this kind of covering being necessary on account of the heat.

The casing, *T,* can be made by a tinsmith out of sheet-iron; the barrel should be 6 ins. inside diameter x 12 ins. long; turn ½ in. over at the top edge and drill three 7-32-in. holes ¼ in. from the top, to hold it by; the space left at the top is for ventilation. There should be a row of ½-in. holes about 1 in. from the bottom, for the same purpose. No provision has been made for an outer globe or shade, as it would be hard to get a stated size; the maker of this lamp will have to see what he can get, and fit it up to suit himself.

The inner globe, 6½ ins. long x 2 ins. top x 1 3-16 ins. bottom and 3 ins. at largest diameter, is one which is in very common use all over the country, and can be purchased from almost all electrical supply houses. The light opal glass is the best globe for indoor use. Any first-class solid carbon can be used, but the builder must see that they are straight and free from "bunches," as otherwise they will stick in the clutch. The carbons are known as ½-in. size, but they are a little larger, running from 0.50 to 0.52 in. diameter. The upper carbon is 12 ins. long and the lower one 5¾ ins. long; one only needs to buy the 12-in. size, as there will be enough of the upper carbon left after the lamp burns out to use for the lower one. ***Do not try to use copper-coated carbons in this lamp.***

The lamp should be connected up as shown by the diagram, Fig. 9. Where the two leads are brought out through the top, they should be taped, or a wood bushing should be used which should be soaked in a paraffin if possible.

A few words of caution may not be amiss. Make sure that the upper carbon is in the upper carbon-holder. Before turning on the current, see that the carbon is free and does not bind in the cap or trip platform. See that all the resistance is in to start with, and cut it out afterward to get the proper adjustment. Make sure that the lamp is connected to the right side of the line; that is, the upper carbon should be the positive one. If there is any doubt as to which wire is positive, start the lamp and let it burn for a few minutes. When switched off, the upper carbon should remain red hot longer than the lower one. If the lower carbon remains hot longer, the lead wires must be exchanged so as to reverse the polarity. The lamp should be adjusted for an 80-volt arc on a 100-volt line, and should take with the above winding 4½ or 5 amperes, according to how it is connected.

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Automatic Block Signal for Railroads.—In this article, published in the September number, the text and caption applicable to Fig. 5 should have read, "Normal clear disc signal on the N. Y., N. H. & H. R. R. at the entrance to Hartford, Conn." In place of "when" in the last line of the first paragraph read "where."

RHEOSTATS FOR DYNAMO LOAD TESTS.

In isolated plants it is frequently desirable to make a full-load test of the machinery, and usually at a time when it is not feasible to put on all of the regular working load. Under such circumstances, it is necessary to have some means of loading the machines to their full capacity, either independent of the working load or in conjunction with it. An apparatus for accomplishing this purpose must, of course, be adjustable so that besides having carrying capacity enough to make up the full load, it can be made to supply whatever difference there is between the working load on the plant at the time of the test and the full load.

The water rheostat is one of the most commonly used forms of apparatus for making up such an auxiliary load for an electrical plant; and, although much fault has been found with it on account of its troublesomeness and unreliability under ordinary conditions, if properly handled it can be made to give excellent results where extreme accuracy is not required, which is just the condition under which the tests referred to above are usually made.

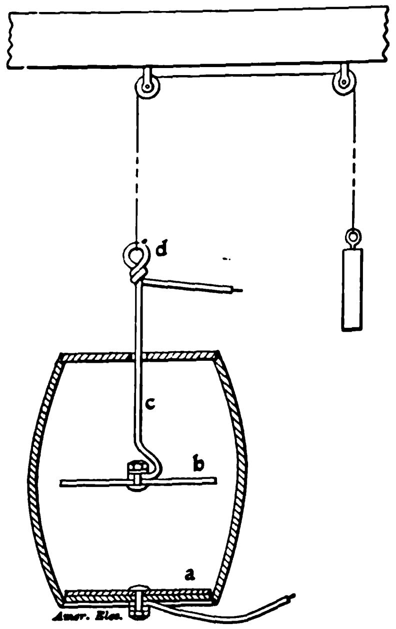

FIG. 1.—SIMPLE FORM OF WATER RHEOSTAT.

A simple form of water rheostat can be made of an old oil barrel and two plates of iron, as shown in Fig. 1. To plate *a,* which is placed in the bottom of the barrel, a stout copper wire is attached, as shown, the free end of which is led to a point at which it can be easily connected to the circuit. To the middle of the other plate, *b,* a stiff piece of insulated copper wire, *c,* should be rigidly attached and carried up through a hole in a piece of board nailed across the top of the barrel. The free end is bent over, as shown at *d,* and then attached to a piece of flexible cable, which is long enough to allow the upper plate to be moved freely up and down. A piece of window cord is tied to the rod at *d,* and passed over a couple of small pulleys screwed into a beam above or into a frame attached to the barrel. Enough weight is fastened to the end of the cord to just balance the movable part of the apparatus, so that the upper plate will remain in any position in which it is placed. If this apparatus is to be used from time to time, it is well to carry the terminals leading from the plates to a knife switch, so that the rheostat may be thrown into the circuit at any time by closing the switch. After the connections have all been made the barrel should be nearly filled with water, and the movable plate lowered so that it is covered to a depth of several inches, after which the rheostat is ready for use.

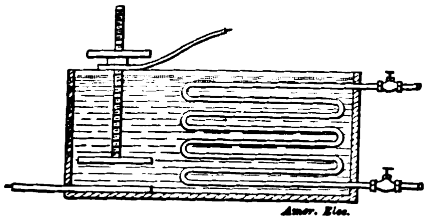

FIG. 2.—COOLING ARRANGEMENT FOR WATER RHEOSTAT.

As pure water is a very poor conductor of electricity, it is necessary to add something to increase the conductivity, such as common salt, sal ammoniac, washing soda, or some other substance which will have the same effect, salt being most frequently used because it can always be obtained easily. The substance used should always be dissolved before adding it to the water and the solution poured in very carefully, because it only takes a small amount to decrease enormously the resistance of the water. However, enough of the solution must be added to make the resistance so low that the rheostat will take the full load without it being necessary to bring the plates very close together. The current-carrying capacity of a rheostat made of a 40-gallon barrel is about 100 amperes for continuous work; more current than this will cause the water to boil violently. When greater capacity is required, several barrels can be used, their plates being connected in parallel.

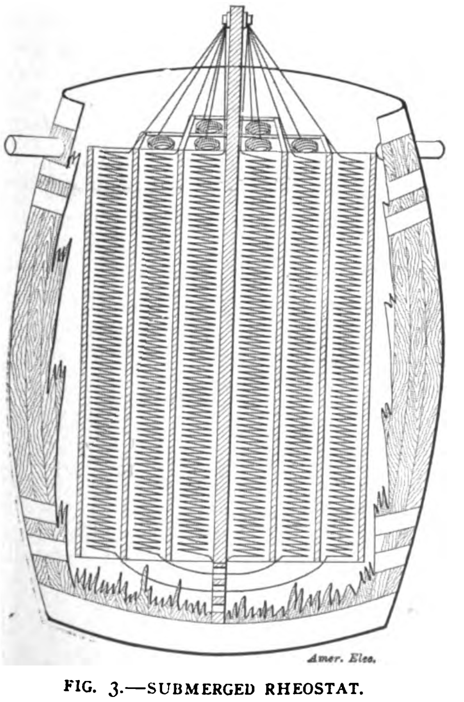

FIG. 3.—SUBMERGED RHEOSTAT.

The trouble from heating can be eliminated by introducing pipes through which cooling water is passed, the rheostat being arranged as shown in Fig. 2. In this case a tank is ordinarily used instead of a barrel. About two-thirds of the space is occupied by the pipes which carry the cooling water, and they should be made of copper on account of its good heat-conducting property. The electrodes are either arranged as shown in the sketch, so that the distance between them can be varied by means of a screw, or the upper one is balanced by a counter-weight as in the case of the barrel rheostat shown in Fig. 1.

Where more constant resistance than can be obtained by means of a water rheostat is desirable, a submerged rheostat should be used. In Fig. 3 is shown a rheostat of this description, which will carry about 800 amperes at 220 volts. A 40-gallon barrel is divided into two main compartments, each of which is subdivided into nine small compartments about 3 inches square, the purpose of the small compartments being to hold coils of galvanized iron resistance wire and also to reduce to a minimum cross-currents between different parts of the coils. There are nine coils, half a coil in each compartment. The diameter of the coils should be about 1¼ inches. Seven of the coils are to be made of 75 feet of No. 14 B. & S. wire, one coil of 60 feet of No. 18 wire, and one of 80 feet of No. 12 wire. Each coil should have leads of No. 6 insulated copper wire joined to the coils at points which will always be at least 3 inches below the surface of the water. When in operation the coils may be connected in series or in parallel, or any combination of the two, so that close regulation can be obtained. Water should be kept circulating through the barrel by means of a ⅜-in. pipe, enough water being used to keep the temperature below 200° F. When in use the barrel should be raised above the ground, so as to avoid seriously grounding the circuit through the stream of cooling water. If it is set up on blocks about two feet high, no trouble will be experienced, because of the high resistance of the small stream of water.

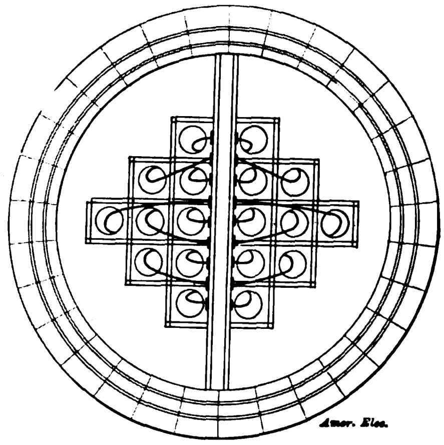

FIG. 4.—TOP OF SUBMERGED RHEOSTAT.

PROPERTIES OF GALVANIZED IRON WIRE FOR SUBMERGED RHEOSTATS.

Wire numbers; B. & S. gauge.	Safe carrying capacity; amperes.	Minimum length in feet for safe carrying capacity at different voltages.				Feet per ohm, hot.
		100	110	220	500	
20	36	22.8	25	50	114	8.5
19	42	24.6	27	54	123	10.4
18	50	26.4	29	58	132	13.5
17	60	27.2	30	60	136	17.1
16	71	29.0	32	64	145	21.5
15	88	31.0	34	68	155	27.2
14	103	32.7	36	72	164	34.2
13	122	34.5	38	76	173	43.2
12	145	36.4	40	80	182	54.3
11	173	38.2	42	84	191	68.6
10	205	41.0	45	90	205	86.5
9	245	42.8	47	94	214	109.1
8	293	46.9	52	103	235	137.5
7	347	50.1	55	110	250	173.5
6	412	53.1	59	117	266	219.0
5	489	56.4	62	124	282	276.0
4	584	59.5	66	131	298	348.0

For the sake of convenience in choosing proper sizes and lengths of iron wire for submerged rheostats, the accompanying table is given. The safe carrying capacities are the currents the wires can safely stand for a continuous run. If the apparatus is to be used for short periods, as in the case of a starting rheostat for a large motor, these values may be doubled.

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INDICATOR DIAGRAMS.

BY CHAS. L. HUBBARD.

Although much has been written upon this subject from time to time, it is one of such importance and interest, especially to younger engineers, that the same ground must be gone over periodically.

Before considering the practical application of the indicator diagram, it is necessary to go back to fundamental principles and show how work, no matter how it is performed, may be represented graphically. A force acting through space produces work; the unit of work is the amount required to raise a weight of one pound one foot in height, and is called a foot-pound; that is, if a pound weight is lifted one foot from the floor a foot-pound of work is performed. Likewise, if by pressing with a force of one pound upon a spring it is compressed one foot, a foot-pound of work is performed; similarly, if a force of one pound acting against a piston moves it one foot, the same amount of work is performed. The product of a force multiplied by the distance through which it acts represents the work done; and if the force is taken in pounds and the distance in feet, the result will be in foot-pounds. For example, the work of raising a 40-lb. weight 80 feet is 40 × 80 = 3200 ft.-lbs. This may be represented graphically by the diagram of Fig. 1. Let the distance on the line *OY* represent the force acting in any given case, and let the distance on the line *OX* represent the space through which it acts. Let each unit of length on the line *OY*

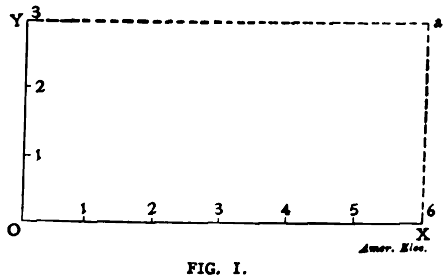

FIG. 1.

represent one pound pressure; then if *OY* be three units and *OX* six units, it will mean that a force of 3 pounds moves through a distance of 6 feet, and the work done will be $3 \times 6 = 18$ ft.-lbs. But this also gives the area of the rectangle *Y O X a*, which is $3 \times 6 = 18$ square units; hence, if two lines are drawn perpendicular to each other and the length of one represents the number of pounds of force acting, and that of the other the distance in feet through which it acts, the area of a rectangle, of which these lines form the two sides, will represent the work done in foot-pounds. In all the cases thus far considered it has been assumed that the force acting was constant throughout the entire distance, but this is not always so. A simple case in which the force is not constant is shown diagrammatically in Fig. 2. A force of 3 pounds moves through a distance of 2 feet, then drops to 2 pounds and moves 2 feet more, then to 1 pound for the remaining 2 feet, the total distance being 6 feet. The area of the work diagram is evidently the sum of the three small rectangles and is $(3 \times 2) + (2 \times 2) + (1 \times 2) = 12$ square feet. The work performed for the first 2 feet is $3 \times 2 = 6$ ft.-lbs.; for the second 2 feet, $2 \times 2 = 4$ ft.-lbs., and for the third 2 feet, $1 \times 2 = 2$ ft.-lbs., making a total of 12 ft.-lbs. By comparing the two results, it is evident that for this case, just as for the first one, the area of the work diagram indicates the foot-pounds of work performed. The area might have been found by taking the average height of the small rectangles and multiplying it by the sum of their lengths. The average height is found by adding the different heights together and dividing by the number of them, as follows: $3 + 2 + 1 = 6$, and $6 \div 3 = 2$, the average height, and $2 \times 6 = 12$ square feet, as before.

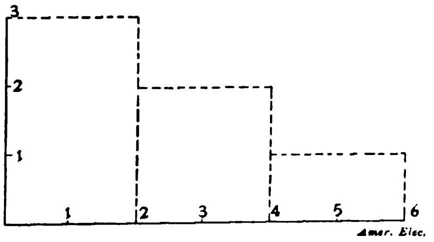

FIG. 2.

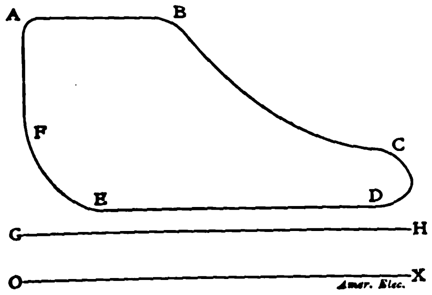

FIG. 3.

If, instead of dropping suddenly at given points, as above, the force varies gradually throughout the movement so that the outer boundary of the diagram is a curved line, the enclosed area will represent the work done just the same as before. If the area and length of a work-diagram are known, the average height may be found by dividing the area by the length; or knowing the foot-pounds of work done and the distance through which the force acted, the average force may be found in precisely the same way by dividing the first by the second.

An indicator card taken from an engine is a work-diagram just the same as those of Figs. 1 and 2, and represents the work done by one stroke of the piston. In Fig. 3, the line *GH* taken before steam is turned into the indicator is called the atmospheric line; its length shows on a reduced scale the length of the stroke. The bounding line *ABC*, above *OX*, represents the pressure above a vacuum acting upon the piston during a forward stroke, and the height of the line *DEF* above *OX* shows the corresponding pressure upon the same side of the piston for different parts of the return stroke. As it would be impracticable to show the actual stroke of the engine upon a diagram the size is reduced by means of a reducing motion which makes the actual diagram about 3 or 3½ inches in length. The vertical dimensions of the card are obtained by placing a stiff spring above the indicator piston. A spring is usually designated as a 10-lb., 20-lb., 40-lb., 60-lb. spring, etc. This means that with a 10-lb. spring the pencil point will be raised 1-10 inch for each pound pressure per square inch in the cylinder, or each 10 pounds pressure will raise the pencil point one inch. With a 20-lb. spring, 1 pound pressure will raise the pencil 1-20 inch, or 1 inch for each 20 pounds, and so on for any other strength of spring used.

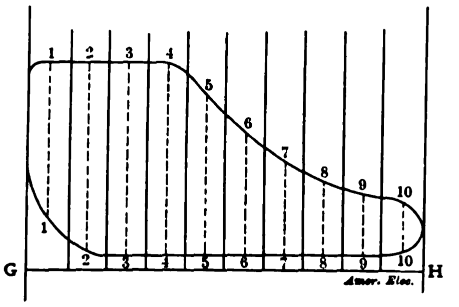

FIG. 4.

It remains to show how the power of an engine may be determined from an actual indicator diagram or card. A horse-power means the performance of 33,000 foot-pounds of work per minute. For example, a 100-h.p. engine is capable of doing 33,000 $\times 100 = 3{,}300{,}000$ ft.-lbs. of work per minute. If the number of foot-pounds of work per stroke of an engine and the number of strokes per minute are known, it is a simple matter to calculate the horse-power, as is shown by the following example: An engine performs 4000 ft.-lbs. of work per stroke and makes 200 strokes (100 revolutions) per minute, required its horse-power, $4000 \times 200 = 800{,}000$ ft.-lbs. of work per minute; $800{,}000 \div 33{,}000 = 24.2$ horse-power. By means of the indicator diagram it is possible to find the foot-pounds of work per stroke. If the steam pressure were constant in the engine cylinder throughout the stroke, this would be an easy matter, for it would be only necessary to multiply the pressure per square inch acting on the piston by the area of the piston in square inches to find the total force in pounds, and this multiplied by the stroke of the engine in feet would give the work done in foot-pounds per stroke. In actual practice, however, the pressure varies throughout the stroke, because the steam supply is cut off before the end of the stroke, and from that point on the steam expands and the pressure gradually falls, as shown in Fig. 3, so that what must be found is not the pressure at the beginning of the stroke, but the mean effective or average pressure acting throughout its entire length. This pressure per square inch multiplied by the area of the piston in square inches, and the product multiplied by the length of stroke in feet, will give the foot-pounds of work done per stroke regardless of the variation of pressure in the cylinder during the stroke. To obtain this case it is necessary to find the average height of the diagram in inches and multiply it by the scale of the spring. There are two common methods of finding the average height of a diagram, or the "mean ordinate," as it is called. One is by erecting a number of perpendiculars along the line *GH*, Fig. 4, and taking the average height of the portions included between the upper and lower lines of the diagram and adding them together and dividing by their number, as was done for the case represented by Fig. 2. The other is by finding the area of the diagram in square inches by an instrument called a planimeter, and dividing the area thus found by the length of the diagram. The first is called the method of ordinates and is shown in Fig. 4. The lines 1, 1, 2, 2, 3, 3, etc., give the average or mean heights of the ten divisions into which the diagram is divided, and can be measured directly from the diagram with a scale reading to 1-100 of an inch. In Fig. 4, suppose that the ordinates have the values given below:

1, 1, = 1.25
2, 2, = 1.48
3, 3, = 1.46
4, 4, = 1.10
5, 5, = .80
6, 6, = .62
7, 7, = .50
8, 8, = .42
9, 9, = .37
10, 10, = .30

8.30

The mean ordinate is $8.30 \div 10 = .83$ inches. Suppose a 60-lb. spring was used in taking the diagram, the mean effective pressure would be $.83 \times 60 = 49.8$ pounds. If the engine made 300 revolutions per minute and had a 16-in. cylinder with a 24-in. stroke, the horse-power would be computed as follows: Area of piston = 201 sq. ins.

Total pressure on piston $= 201 \times 49.8 = 10{,}009.8$ lbs.

$10{,}009.8 \times 2$ (ft.) $= 20{,}019.6$ ft.-lbs. per stroke.

$20{,}019.6 \times 600 = 12{,}011{,}760$ ft.-lbs. per minute.

$12{,}011{,}760 \div 33{,}000 = 363.9$ horse-power.

In making a careful calculation for the horse-power of an engine, it is customary to take cards from both ends of the cylinder and compute the mean effective pressure of quite a number of each, and then take the average of the whole number in making the final calculation for the total horse-power of the engine. In the case of the crank end of the cylinder, the area of the piston-rod should be deducted from the area of the piston.

The whole operation may be stated in the form of a rule as follows: Find the mean effective pressure, either by the method of ordinates or by the use of a planimeter; multiply this by the area of the piston in square inches; multiply this result by the length of stroke in feet, and the product by the number of strokes per minute. The final product divided by 33,000 will give the horse-power of the engine.

When a large number of cards are to be worked out and the speed of the engine is practically constant, it is often convenient to first compute what is known as the "engine constant." This is found by multiplying together the area of the piston, the length of stroke and the number of strokes per minute, and dividing the product by 33,000. This quantity multiplied by the mean effective pressure of any diagram will give the horse-power as indicated by that particular one, or if it is multiplied by the average mean effective pressure of all the cards it will give the average horse-power for the whole test.

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TWO-WIRE INTERCOMMUNICATING TELEPHONE SYSTEMS.

BY H. S. WEBB.

By a two-wire intercommunicating telephone system is meant one that has two wires for each telephone station in addition to the two wires used in common by all the stations in some systems for signaling purposes only. This title has been chosen for lack of a better one, although it may not be very accurate or definite. The object of using two independent wires for each telephone station is to eliminate cross-talk. Where cross-talk to a moderate degree is not very objectionable, the older systems (using one wire for each station in addition to one or two common signaling wires) are cheaper to install, simpler, and give good satisfaction. However, where the wires are run in cables, as is now usually the case in first-class installations of intercommunicating systems, and all cross-talk must be eliminated, it is necessary to use a two-wire system of some kind.

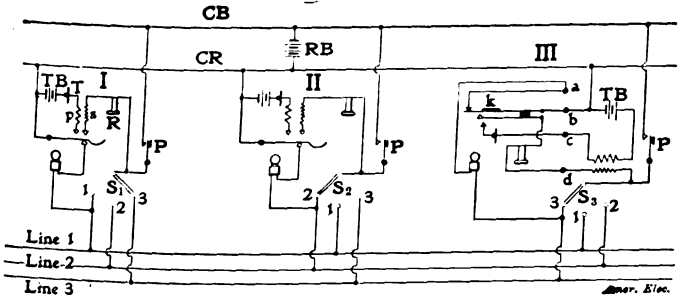

FIG. 1.—ONE-WIRE TELEPHONE SYSTEM.

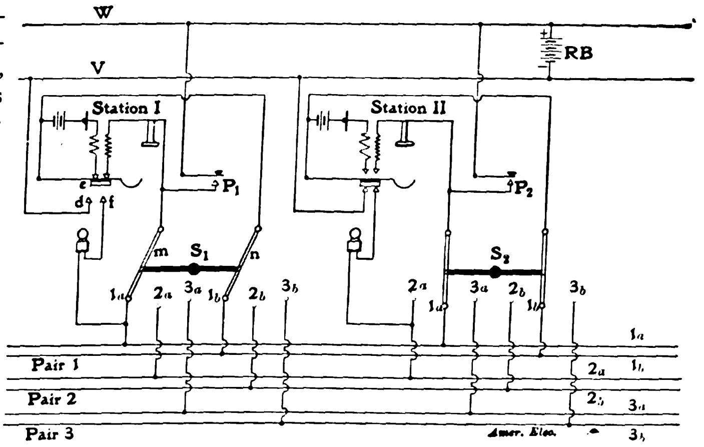

FIG. 2.—TWO-WIRE TELEPHONE SYSTEM.

Before taking up two-wire systems it may be well to consider briefly what may be called for distinction, a "one-wire" system. An excellent one-wire system is shown in Fig. 1. It has one common battery, *RB*, used by all the telephones for ringing purposes and a battery at each telephone for operating the transmitter. The connections at stations 1 and 2 represent an ordinary wall telephone, and at station 3 a so-called microtelephone set, having the transmitter and receiver mounted in one handle suitable for holding the transmitter before the mouth and the receiver to the ear at the same time. There is usually mounted in the handle a simple push-button switch that may be conveniently held closed by the hand while talking. Four wires starting at *a*, *b*, *c*, *d*, in the handle, run to the talking battery and to the box containing the bell, or buzzer, the induction coil, the push button, *P*, and the switch, S_3.

To call a station it is merely necessary to turn the switch to the number of the station desired, press the push button, *P*, to ring the bell, and then remove the receiver from the hook. When the conversation is finished the switch should be returned to the first or so-called "home" position. However, if the user should neglect to do so, that station can still be called up from any other station, but nothing can be heard, and hence no conversation can be carried on, till the switch at the station called is returned to the home position. Hence if the bell rings but the person answering the telephone call hears nothing when he takes down the receiver, he knows, or soon learns, that he must turn the intercommunicating switch to the home position. The advantage of this arrangement will be apparent when it is stated that if the wiring were such as not to require the returning of the switch at the station called to the home position before the conversation could be carried on, and if a number of switches should happen to be left off the home position and, especially, if several switches happened to be left on the same numbers, the talking current would be divided among the several stations that happen to be in parallel. Consequently the operation would be poor, and the two persons conversing would be unable to remedy the trouble, for they would have no convenient way of determining what stations were the cause of it.

All things considered, this is the best arrangement the writer has seen where no automatic device restores the switch to the home position when the receiver is hung up, and where there are only one or two wires common to all stations in addition to one wire for each station. In this system there is one wire for each telephone and two more wires used in common for all the telephones. One wire, *C B*, is used merely for connecting one terminal of the ringing battery, *R B*, to each push button, *P*. The other wire, *C R*, is used not only as a common return for the ringing currents, but it is also a common return for the talking currents.

It will be seen that Stations *I* and *II*, using line 1 or 2 as a part of their talking circuit, and Stations *III* and *IV* (the latter is not shown), using line 3 or 4 as a part of their talking circuit, could hold conversations without any interference due to cross talk, but if Stations *I* and *IV* using line 1 or 4 and Stations *II* and *III* using line 2 or 3 were conversing, there might be considerable cross-talk due to induction between these lines, and also to the use of one wire as a common return by all the telephones as a part of their talking circuits. Hence, if one wire in use by one pair of telephones overlaps the wire in use by another pair of telephones there is very apt to be more or less cross-talk.

This can be avoided by holding each conversation over two independent wires; that is, by using what is here termed a two-wire system. It corresponds to what would be called a complete metallic circuit in a telephone exchange system. If the wires for an intercommunicating system are run in cables, as is usually the case, each pair must be twisted together, as in ordinary telephone cables used in complete metallic exchange systems. If not in a cable then the pairs must be fairly well separated, and if the various pairs run parallel to each other for any distance the wires forming each pair should be properly transposed in order to eliminate cross-talk due to induction. This, of course, has nothing to do with cross-talk due to poor insulation, such as a damp cable.

About the simplest way to convert the system shown in Fig. 1 into a two-wire system is shown in Fig. 2. A contact piece, *e*, is fastened to, but insulated from, the hook switch, in such a manner as to close the circuit between *d* and *f* when the telephone receiver rests on the hook. A double switch, *S*, is also required. The latter may be made in a variety of ways, but is here shown in a simple form in order that th connections may be clearly seen. The two levers, *m* and *n*, are mechanically fastened together so that moving one handle will move both levers; but the two levers mus be insulated from each other; *P* is a simple push-button switch. One common an centrally located battery, *R B*, is used for ringing the bell at any station.

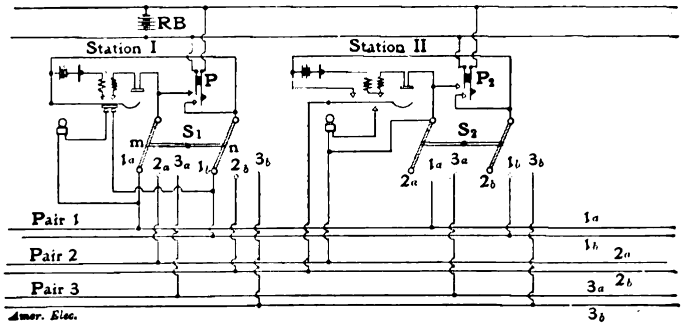

FIG. 3.—TWO-WIRE SYSTEM WITH AUTOMATIC SWITCH.

To call up a station the switch, *S*, is turned until the straps, *m* and *n*, rest on the buttons of the number of the station desired and the push-button pressed. It makes no difference whether the receiver at the station where the call originates is on or off the hook. Suppose Station *II* is calling up Station *I;* then current flows from *R B* through P_2—contact 1—wire 1*a* —bell at Station *I*—*f-e-d-V* back to *R B*, and hence does not pass through any hook-switch contacts at Station *II*. Moreover, it is not necessary for the switch at Station *I* to be at the first, or home, position in order to be able to ring the bell there, because it has just been shown that the ringing current does not pass through any part of the selective switch at the station to be called; in this case switch S_1 at Station *I*. However, the levers, *m* and *n*, at the station called, must rest on, or be returned to, their home positions before any conversation can be carried on. When ringing, only one wire of a pair is used, the wire, *V*, serving as a common return; but when conversing, both wires of one pair are in use, and neither the wire, *IV*, nor *V*, is then used; thus there can be no cross-talk due to induction. The ringing current would probably cause little or no trouble by induction between wires, but the writer has had no opportunity to test this particular arrangement.

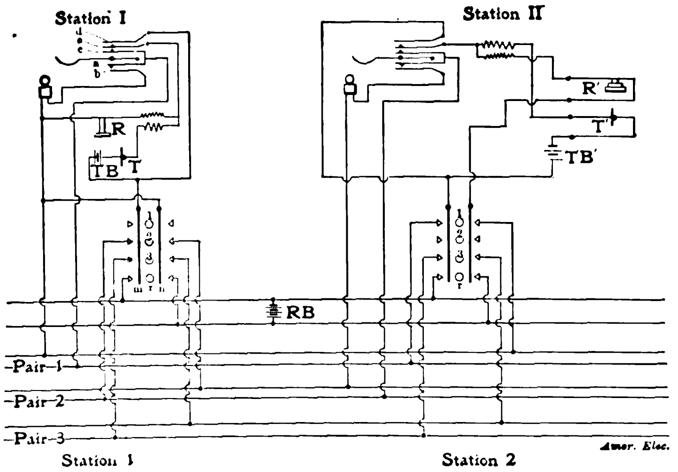

FIG. 4.—COUCH & SEELEY AUTOMATIC SWITCH SYSTEM.

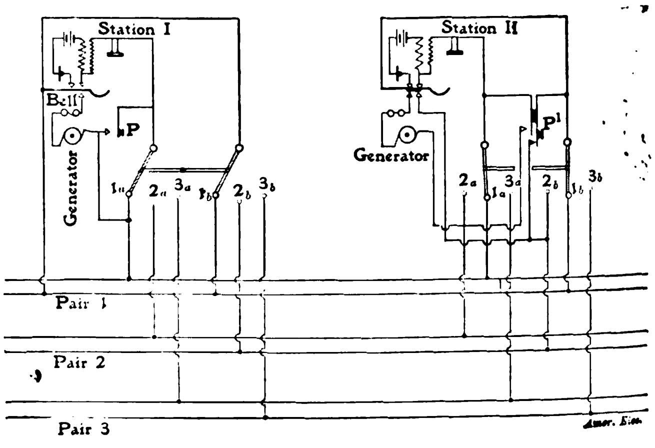

FIG. 5.—AUTOMATIC TELEPHONE SYSTEM WITH MAGNETO BELLS.

By means of a double contact push-button switch even the ringing current can be made to flow through both wires of one pair and all danger of induction troubles from the ringing current as well as from the talking current, may be eliminated. Such an arrangement is shown in Fig. 3, where Stations *I* and *II* are a little differently wired for reasons to be presently explained. When the double-contact push, *P*, is pressed, the ringing battery, *R B*, is connected to the levers, *m* and *n*, and the bell at any station desired may be rung. For instance, if Station *I* calls Station II, the ringing surrent will flow from *R B* through *P*—*m*—button 2*a*—wire 2*a*—bell at Station *II*—hook switch—wire 2*b*—contact 2*b* at Station *I*—lever, *n*, back through the push, *P*, to battery *R B*. The wiring at Station *I* is so arranged that the station can be called up from any station, no matter in what position the intercommunicating switch S_1 may have been left. However, the wiring at this station has been purposely so arranged that the switch must be returned to the home position before anything can be heard in the receiver, when this station is called by some other. The advantage of this arrangement is the same as already explained in connection with the system shown in Fig. 1. When automatic switches are used the trouble last mentioned is eliminated because the switch is automatically restored to the home position when the receiver is hung up. At Station *II* in Fig. 3 the connections are suitable for use with an automatic switch.

Fig. 4 illustrates diagrammatically an excellent automatic switch system made by the Couch & Seeley Company, of Boston, in which practically the same wiring system is used as that shown at Station *I* in Fig. 3. In Fig. 4, *m* and *n* represent two metal pieces used in place of the levers shown in Fig. 3. By pressing in the push-buttons, 1, 2, 3, or *r*, the corresponding contact springs on each side are firmly held against the pieces, *m* and *n*. The springs corresponding to the home station (opposite push 1 at Station *I*, and opposite pus 2 at Station *II*) are blank, as they are not used. The push, *r*, at the bottom is used for ringing purposes. Unlike the other pushes, it returns to its normal position as soon as released. The other pushes only return to their normal positions when the receiver is placed on the hook.

To call up Station *II*, for instance, th button, 2, at Station *I* is pressed and it will remain in; then the ringing push-button, *r*, is pressed and the receiver removed from the hook. When the conversation is ov and the receiver is hung up, a very ingenious and substantial mechanism will allow the selective button that was presse in to spring out into its normal position If desirable two or more buttons may be simultaneously pressed so that several parties may be called at once and a consultation held. This is often a very convenient feature in large factories and other establishments. The switch will readily restore any number of buttons to their normal positions. Any number of pairs of telephones may be in use at one time without disturbing one another, either while talking or ringing. This system requir a pair of battery wires in addition to one pair of wires for each telephone.

If magneto bells and generators are included in each telephone set instead of an ordinary vibrating bell, then the ringing battery and the two battery wires will not be required, and the connections would be as shown in Fig. 5. This arrangement requires only one pair of wires for each telephone. At Station *I* the wiring is so arranged that only a simple push-button, *P*, is required for ringing purposes, while the wiring at Station *II* requires a double contact push, P^1. The wiring at this latter station gives a more evenly balanced system, perhaps, but it does not seem to possess any actual superiority over that at Station *I*, which is the simpler of the two. At Station *II* a double contact push and an insulated contact piece on the under side of the hook switch are required.

Of course, an automatic device can als be applied to return the switches in Fig. 5 to their home position when the receiver is hung up. The Couch & Seeley Compan uses the form of automatic switch indicated in Fig. 4 for a magneto bell-generator system, the wiring shown at Station *II*, Fig. 5, being employed in connection with it.

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PARALLEL OPERATION OF ALTERNATORS.

BY F. HARDIE JEANNIN.

In order that alternators may work properly in parallel the voltages must be alike, and the frequencies the same; the pressure curves must have the same form; each machine must take its proportional share of the load under the varying conditions of the service; the wattless or synchronizing current which passes between the machines, but not into the external circuit, must be small; the machines must be of the same type; and finally, the direction of rotation of the machines, electrically speaking, must be the same. The first six points have been so well covered by articles which have appeared from time to time in the scientific papers that there is no need of going over them again, so that only the last point will be considered here.

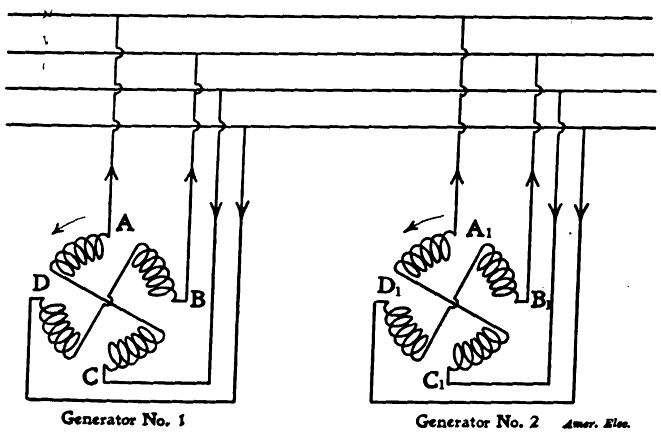

FIG. 1.

In the case of two quarter-phase machines having two separate circuits and running in the same direction, the connections will be similar for the two machines. This is shown diagrammatically in Fig. 1. The arrows show the direction of rotation, and similar points on the two machines are lettered alike. The arrow heads show the direction which the currents in the wires on which they are placed may be assumed to have at any instant. It will be noted that the leads from corresponding points on the two machines are carried to the same bus-bar, and also that the currents in them have the same direction. For example, the lead from point A on generator No. 1 and the corresponding point, A_1, on generator No. 2 go to the same bus-bar, and the arrow head on each wire points upward.

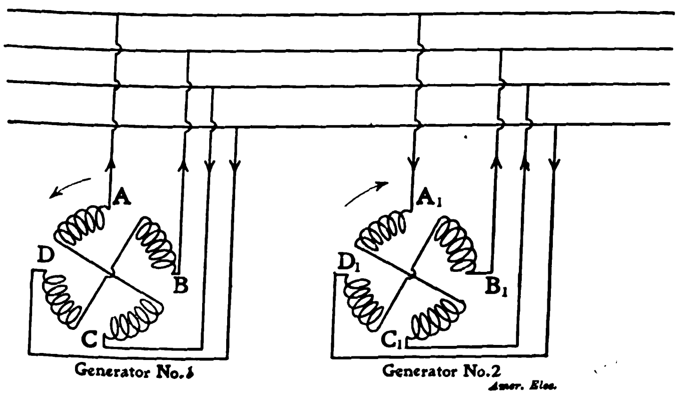

FIG. 2.

If the direction of rotation of generator No. 1 is kept the same, while that of No. 2 is reversed, the direction of the currents in the two machines will be such that they will not run in parallel as originally connected. Fig. 2 shows diagrammatically this case. If one of the phases, B_1D_1, of generator No. 2 be brought to synchronism with the corresponding phases, B_1D_1, of generator No. 2 be brought seen from the diagram that the other phase, A_1C_1, is out of phase with $A\ C$. If the leads from A_1 and C_1 are interchanged the machines will be properly connected. The arrangement, after this change has been made, is shown diagrammatically in Fig. 3, upon inspection of which it will be seen that the currents in the wires have the proper directions for parallel operation. This might have been accomplished by leaving the connections of generator No. 2 the same as they are shown in Fig. 2 and transposing the leads from A and C on generator No. 1. If the phase A_1C_1 be brought to synchronism with $A\ C$ it will be found that the other phase is out of synchronism, and that in order to bring it to synchronism it will be necessary to transpose either B_1D_1 or $B\ D$. From the above it is evident that if two quarter-phase machines are connected to run in parallel and the direction of one of them is reversed it will be only necessary to reverse the leads of one of the phases of either one of the machines in order to make them run properly under the new condition of things.

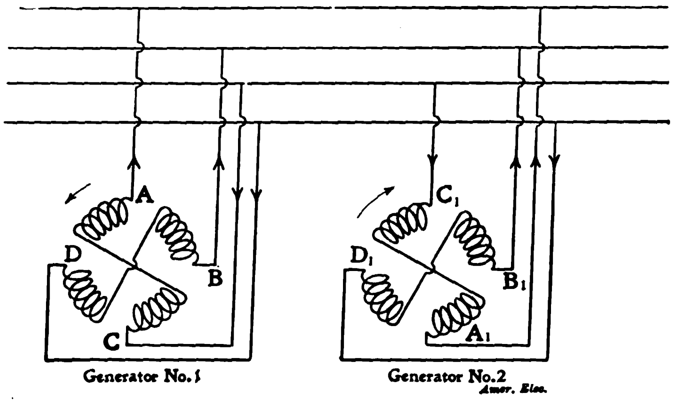

FIG. 3.

In the case of two two-phase alternators operating in parallel on a three-wire system, if the direction of rotation of one of the machines is reversed the connection of the common return will have to be changed at one of the machines. This is shown diagrammatically in Fig. 4, the change having been made on generator No. 2. Before reversing generator No. 2 both machines would have the same connections as shown for generator No. 1.

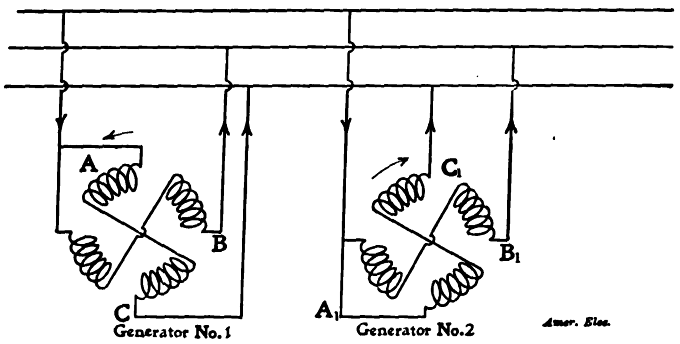

FIG. 4.

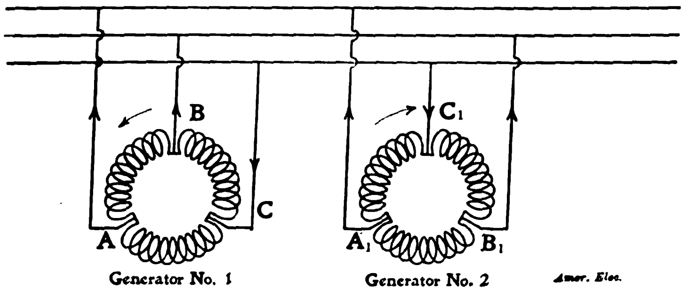

FIG. 5.

The case of three-phase, delta-connected machines running originally in the same direction, where the direction of rotation of one of them (generator No. 2) has been reversed, is shown diagrammatically in Fig. 5. Each of the machines was originally connected as shown for generator No. 1, and in order that they may run properly when one has been reversed it is only necessary to interchange the leads of any one of the phases of either machine. In this case the leads B_1C_1 of generator No. 2 have been interchanged. Fig. 6 shows diagrammatically the same thing for two Y-connected machines, one of which (generator No. 2) has been reversed. As in the case of delta-connected machines, it is simply necessary to transpose the connections of any phase of either machines. In this case B_1 and C_1 of generator No. 2 were interchanged.

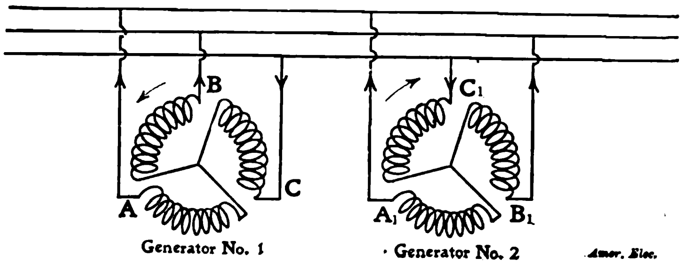

FIG. 6.

In the case of separately-excited composite three-phase machines where the compounding is obtained by means of a current transformer having three primary windings and one secondary, owing to the fact that one primary winding is reversed with respect to the other two, one of the two leads to be transposed must always be the lead connected to the reversed primary winding of the transformer.

After the changes of leads are made, care must be taken before attempting to start the machines to have the synchronizers properly connected, which connection is, of course, between the corresponding leads of the two machines which go to the same bus-bar.

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Enormous Turbine Unit.—Brown, Boverie & Co. are building for the Essen Electricity Supply Works a turbine direct-connected to a 5000-kw. alternator and a 1500-kw. generator. The steam consumption is less than 15½ lbs. per kilowatt-hour.

Lessons in Practical Electricity

THE WATTMETER.

As has been explained in a previous lesson, the power in an electric circuit is expressed in watts or kilowatts, a kilowatt being a thousand watts. For direct-current circuits, the power in watts may be found by multiplying together the current in amperes and the e.m.f. in volts; this may be reduced to horse-power by dividing by 746.

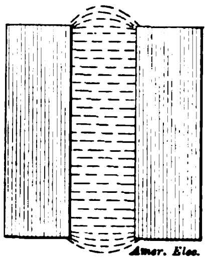


FIG. 4.

As it is often necessary to measure the power of a circuit directly, an instrument for this purpose has been devised, which is called a "wattmeter." The readings of a wattmeter must evidently be proportional to the product of the volts and amperes of the circuit; this is usually obtained by means of the electromagnetic reactions between a movable fine-wire coil and fixed coarse-wire coils. Fig. 1 shows diagrammatically the arrangement of an instrument of this description; coarse-wire coils, *m, m*, are placed one on each side of the frame, *k*, and are arranged so as to develop opposite polarity at the sides facing one another. The moving coil, *c*, which is made of fine wire, is pivoted in the frame, *k*. It is held in normal position by two spiral springs, *a*, one above and one below, which also serve to make electrical connections with the coil. In this position, a pointer, *p*, which is attached to the coil, *c*, stands at the zero mark on the scale, *s*. The actual arrangement of the moving coil, frame, springs and pointer is shown in perspective in Fig. 2. In order to measure the power of a circuit, the terminals of the fine-wire moving coil are connected to the two sides, *a* and *b*, of the circuit, as shown diagrammatically in Fig. 3, and the coarse-wire coils in series with the circuit, as shown at *d, d*.

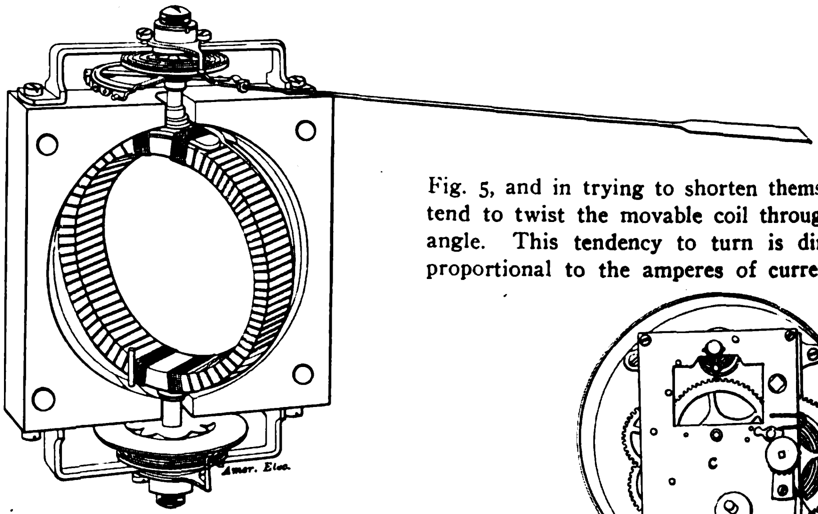
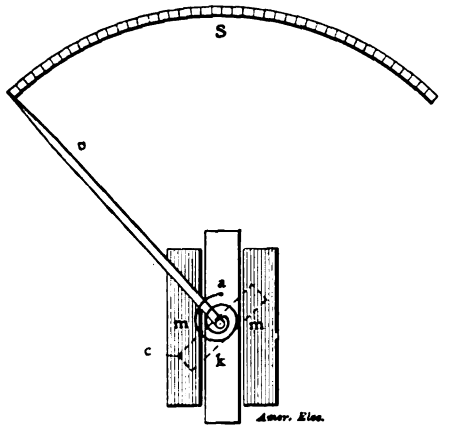


FIG. 2.—INTERNAL ARRANGEMENT OF WATTMETER.



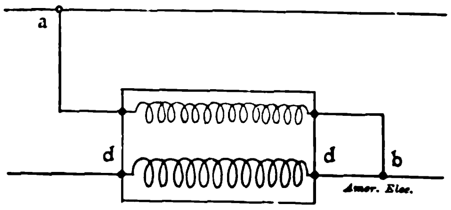


FIG. 1.—WATTMETER AND DIAGRAM OF WATTMETER CONNECTIONS.—FIG. 3.

As the resistance of the moving coil is constant and it is connected across the circuit, the current in it is proportional to the e.m.f. at the terminals of the instrument; and as the coarse-wire fixed coils are in series with the circuit, the current in them is the whole circuit current. If the fine-wire coil carried no current, the direction of the lines of force set up by the current in the coarse-wire coils would be approximately straight, as shown in Fig. 4, in the space between the coils; but on account of the field set up by the current in the movable coil, the lines are distorted, as shown in Fig. 5, and in trying to shorten themselves tend to twist the movable coil through an angle. This tendency to turn is directly proportional to the amperes of current in the stationary coils multiplied by the current (and therefore the e.m.f.) of the movable coil. In formula shape,

$$T = E \times I \times k,$$

in which T represents the rotary pull or

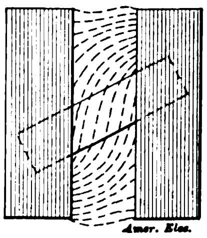


FIG. 5.

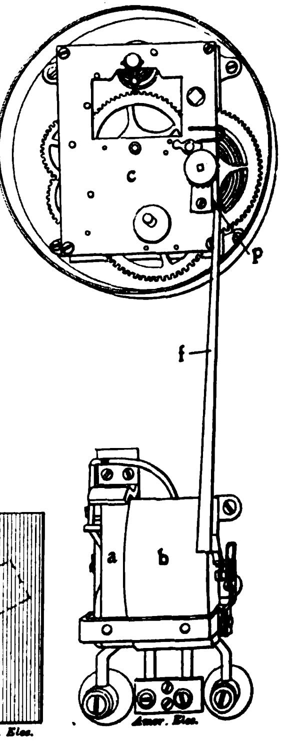


FIG. 6.—RECORDING WATTMETER.

torque; *E,* the e.m.f at the terminals of the movable coil; *I,* the current in the stationary coils, and *k,* a constant, depending on the units in which *T* is reckoned. The retractile effort of the springs increases directly as the angle through which the movable coil is pulled, so that the watts indicated will be

$$P = EI = a \times k,$$

a being the angle of deflection. It is customary to make the scale of a wattmeter read watts and not angular degrees, so that in commercial forms of wattmeters the pointer indicates watts.

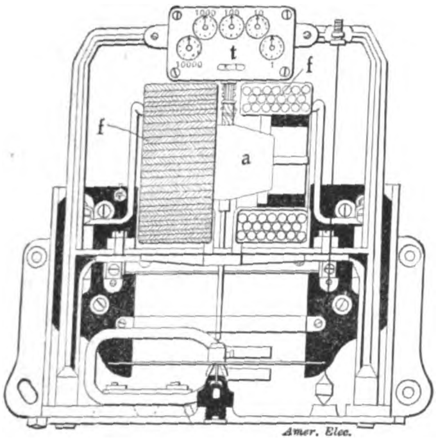


FIG. 7.—INTEGRATING WATTMETER.

Where a continuous record is desirable and great accuracy is not required, a recording wattmeter arranged as shown in Fig. 6 may be used. The operation of an instrument of this description depends upon the principle that two solenoids will attract each other if placed near together and arranged so that the adjacent ends are of opposite polarity.

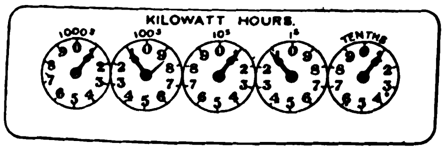


FIG. 8.—INTEGRATING WATTMETER DIALS.

The coil, *a,* which is of fine wire, is mounted on knife-edge and spring supports, and is free to move toward the stationary coil, *b,* which is wound with wire heavy enough to carry the entire circuit current. The terminals of the high-resistance coil, *a,* are connected across the circuit, and those of the low-resistance coil, *b,* in series with the circuit, so that the magnetic effect of the coil, *a,* is proportional to the e.m.f. of the circuit, and that of the other, *b,* to the circuit current; therefore the magnetic effect of the two coils upon each other is proportional to the product of the e.m.f. and current of the circuit. The arm, *f,* is attached directly to the knife-edge of the moving coil, and moves with it, and hence with the coil. At the upper end of the arm a pen, *p,* is fastened, which rests upon a chart marked with radial lines, which indicate time, and circles, which indicate watts. The chart is uniformly driven by a clock, *c.* When current passes through the coils, the fixed one, *b,* attracts the movable one, *a,* thus causing the pen, *p,* to move away from the center of the chart, and the movement of the chart causes the pen to draw a continuous line, which indicates at any time the watts of the circuit.

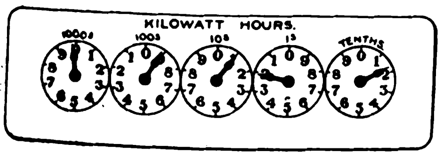


FIG. 9.—INTEGRATING WATTMETER DIALS.

A form of meter which is universally used to measure the electricity furnished by electric companies to consumers is shown in Fig. 7. It is sometimes called an "integrating wattmeter," but really it is a watt-hour meter, because it registers the time as well as the watts. It is arranged so that it will run when the current is passing, and will stop when the current stops. It is made in the form of a small motor, which drives a delicate train of gears. On the gears are fastened pointers, which indicate on a set of dials the number of watt-hours supplied. The armature, *a,* which is made of fine wire, is connected in series with a high resistance across the mains, the combination forming the voltmeter circuit of the instrument, and the current in this part of the meter circuit is directly proportional to the voltage at the terminals of the instrument. The field magnet, *f, f,* are two coils of large conductors, and one is placed on either side of the armature. They are connected in series with each other, and in series with the circuit, forming the ammeter circuit of instrument. As the armature and field coils contain no iron, the magnetic field due to each of them is proportional to the currents in them respectively. The resultant rotary effect is proportional to the product of the e.m.f. and amperes of the circuit, as has already been explained in a previous lesson for a direct-current motor. A wattmeter of this description does not run faster when the field current is increased as an ordinary motor would, because the load that is imposed on the armature is relatively great, and the resistance is so high that the counter e.m.f is inappreciable, so that the speed is controlled solely by the torque between the field flux and the armature wires. An ordinary motor would run in the same way if its armature winding had a very high resistance, and the field flux were weakened beyond the point where the product of the field flux and ampere-turns is sufficient to give the torque required by the load. The dials, *t,* are usually graduated so that the pointers indicate kilowatt-hours (1000 watt-hours).

The figures 1000, 100, 10, 1, and tenths, Fig. 8, refer to the divisions of the circles just below them. For example, the divisions on the circle to the right of the cut indicate one, two, three, etc., tenths of a kilowatt-hour; a complete revolution of the pointer would indicate ten tenths or one kilowatt-hour, and at the same time the pointer on the second circle would move so as to indicate one kilowatt-hour. The reading of the instrument is 1111.1 kilowatt-hours; it is obtained by beginning at the right and reading each dial in succession toward the left. The first pointer indicates 0.1, the next 1, the next 10, the next 100, and the last one toward the left 1000, so that the combined reading is 1111.1. Similarly, the reading of the dials shown in Fig. 9 is 9912.1.

A pointer to be read as having reached the division on which it seems to stand must always be confirmed by the dial just to the right of it. It has not reached the division on which it may appear to rest unless the pointer to the right of it has reached or passed the zero mark, or in other words, completed a revolution; therefore it is always safer to read the dials from right to left, instead of starting at the other side, as one would naturally do.

In order to get the kilowatt-hours supplied during a given time, the difference between the readings of the meter at the beginning and end of the time is taken; thus, if the reading of the instrument at the beginning of a month is 9912.1, and at the end 1111.1, the kilowatt-hours for the time are 9912.1 — 1111.1 = 8801.0. With some of the meters of this general type, it is necessary to multiply the indicated wattage by a constant in order to get the kilowatt-hours; in such cases, it is customary to mark the constant on the dial plate of the instrument.

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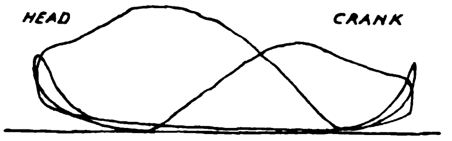
Wind-Driven Electric Plants.—This was the subject of a lecture by Prof. P. la Tour, recently delivered before the Copenhagen Technical Congress. On behalf of the Danish Government, the author has for many years been engaged in experiments on the use of wind-motors in connection with the operation of electric generating plants, the results being fairly satisfactory. The main drawback has been the difficulty in obtaining approximately constant speeds, irrespective of the strength of the wind. It is reported that this difficulty has been overcome by the use of an intermediate shaft placed on a sort of balance; the transmission belt from the windmill leading horizontally down to the pulley of this shaft, and the pressure of the belt against it being regulated by means of the balance provided with convenient counter-weights. From the intermediate shaft another belt leads to the dynamo, it being found practicable by this arrangement to make the transmission belt from the mill slip on the pulley as soon as the load exceeds a given value, enabling the mill to run at any speed without carrying the speed of the dynamo above a certain limit. By means of this arrangement in connection with a maximum and minimum interrupter, inserting the machine automatically as soon as conditions are favorable, and switching it off again as the wind becomes too weak, the author claims to have obtained excellent results, the plant having proven satisfactory even during the strongest storms. As a matter of course, storage batteries are always used in connection with such plants. A small station equipped according to this plan is said to have been in operation at Askoo, Denmark, ever since October, 1902, about 450 incandescent lamps being lighted with excellent results; a petroleum motor is provided as a reserve in case of several days' calm weather.

Letters on Practical Subjects

Freak Indicator Cards.

To the Editor American Electrician:

The enclosed indicator cards, taken from a 22 in. x 48 in. Allis Corliss simple, horizontal, non-condensing engine operating at 100 r.p.m. under an initial steam pressure of 125 pounds, may be of interest to some of your readers. Having discovered the cause of their peculiar appearance, I am somewhat curious to know if any other of your readers can account for it.



FREAK INDICATOR CARDS.

Colorado Springs, Colo. C. E. BIBB.

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A Curious Effect From Lightning.

To the Editor, American Electrician:

While conducting some experiments in wireless telegraphy recently, the writer left a coherer connected up, one terminal to a lightning rod and the other to a zinc plate, the lightning rod connection being utilized as a ground. The zinc plate and coherer were thoroughly insulated and located within doors; the lightning rod, of course, was on the outside of the building. During the night, while the coherer was left thus connected up, a severe electrical storm occurred. Upon going to the laboratory the next morning, I found the coherer tube melted in two, the iron and copper filings blackened and burned, and the sealing wax which had surrounded the coherer tube melted off. I should like to have expressions of opinions from the readers of the AMERICAN ELECTRICIAN as to the cause of this result. The only solution that I can offer is that the capacity of the zinc plate caused the lightning discharges to oscillate between the lightning rod and the plate and overheat the filings sufficiently to melt the tube. LEO DOLKART.

Chicago, Ill.

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A Question in Static Electricity.

To the Editor American Electrician:

While I was adjusting the pop valves on a locomotive recently a strange phenomenon occurred, which I think would be of interest to the readers of the AMERICAN ELECTRICIAN. As long as the steam was escaping through the valve there was a steady stream of sparks from the valve to the wrench in my hand, even when it was held an inch from the valve, which continued for a short time after the valve was shut. I was standing on top of the cab which, was covered with tar paper, and consequently was well insulated from the ground, and as the day was wet and the valve therefore well grounded I do not understand why the discharge should not have passed directly to the ground instead of to the monkey wrench in my hand. LOUIS T. ANDRE.

South Knoxville, Tenn.

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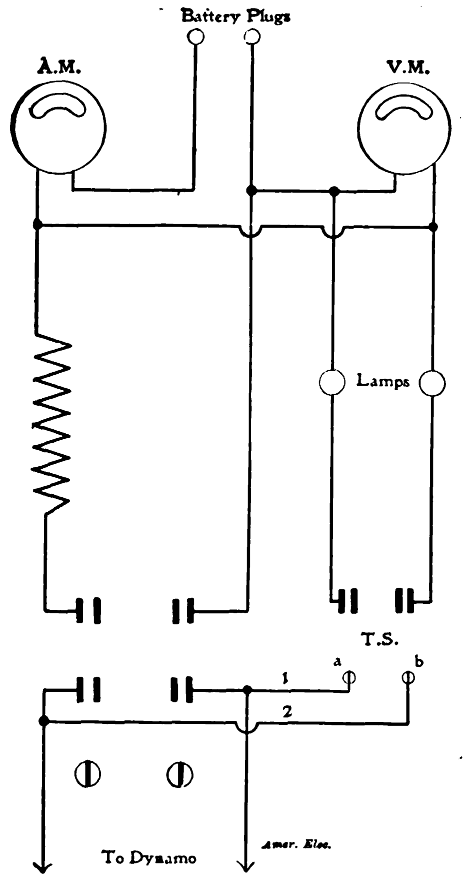
Testing the Polarity of Battery Connections Without a Polarized Voltmeter.

To the Editor, American Electrician:

The accompanying diagram indicates one method of connecting up a storage battery charging board, such as the kind used for charging automobile batteries, by means of which correct connections may be insured when one has not a polarized or permanent-magnet voltmeter. The test connection is made from the charging main through a small switch, *T S*, and two 110-volt lamps, as indicated in the sketch. When the batteries have been connected to the charging plugs the testing switch is closed, the main switch being left open, of course. If the batteries are connected wrong, their voltage will be added to that of the charging dynamo; therefore, if the dynamo is a 110-volt machine and the battery contains 40 cells the resulting voltage will be approximately 110 + 80 = 190 volts and the lamps will be very nearly up to full candle-power. On the contrary, if the connections are correctly made, the voltage at the lamps will be the difference between the dynamo e.m.f. and that of the storage battery, or under the conditions just mentioned, approximately 110 — 80 = 30 volts, and the lamps of course, will be absolutely dark. The main charging switch can then be closed. This method is open to the objection that a broken filament in one of the lamps will cause them to indicate correct connections even if the connections are wrong; this, however, is not a serious drawback for the reason that the ammeter, if at all sensitive, will serve as a check. When the connections are right, the current will be so small that the ammeter needle will probably not move, and when the connections are wrong the current will be much greater; in the example just quoted, correct connections would cause a current of about 0.07 ampere to flow through the ammeter, and with wrong connections the current would be about 0.43 ampere.



TESTING BATTERY CONNECTIONS.

Chicago, Ill. W. S. BURY.

[It is evident that if the wires 1 and 2 were transposed at the test switch, 1 being carried to *b* and 2 to *a*, then the lamps would glow when the battery was correctly connected, and a broken filament could not cause trouble by incorrect indication.—EDITOR.]

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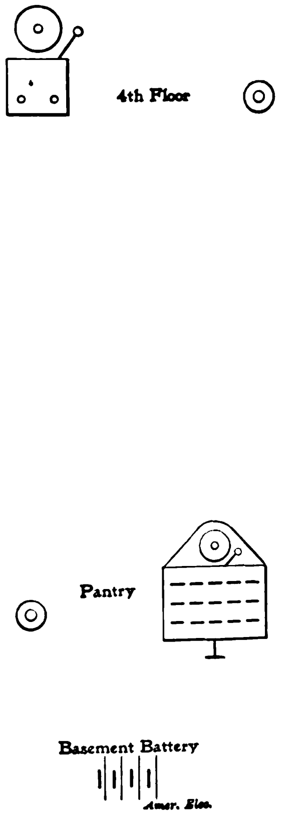
A Problem in Bell Wiring.

To the Editor American Electrician:

The accompanying sketch indicates an ordinary vibrating bell and a push-button located on the fourth floor of a building, a 15-drop annunciator and a push-button located in the pantry, and a battery in the basement. The push-button on the fourth floor is connected in the usual manner to the proper drop in the annunciator, and it is desired to establish connections between the push-button in the pantry and the bell on the fourth floor, so that the latter may be rung from the pantry, but no new wires must be run, nor must the gas pipes or other ground be used to complete the extra circuit. I should like very much to have readers of the AMERICAN ELECTRICIAN suggest methods by which these results may be accomplished. CHARLES W. PETRY.



PROBLEM IN BELL WIRING.

Washington, D. C.

Queries and Answers

IMPORTANT.—No attention will be given to inquiries which do not give the full name and address of the inquirer.

Can the 2-h.p. single-phase motor described in the September number be operated on a 60-cycle circuit without changing the winding, and if so, what would be the speed and power? J. E. P.

Yes; the speed would be approximately 1200 r.p.m, and the power slightly less than one horse-power.

What is the direct-current voltage of the single-phase rectifier described in "Electrical Designs" if the e.m.f. of the alternating current delivered to the machine is 105 volts at 60 cycles? (2) Will the rectifier pass sufficient current to operate a ⅓-h.p. motor satisfactorily, provided the motor is wound for the direct-current voltage of the rectifier? H. G. D.

The direct-current e.m.f will be approximately 148 volts, irrespective of the number of cycles of the supply current. (2) Yes.

What would be the inductive effect between a 2000-volt, single-phase line and a 10,000-volt, three-phase line strung parallel for a mile and a half, the wires of the two lines being within eighteen inches of each other? The two lines are on different sets of poles. M. J. I.

The effect would probably be negligible, since the inductive effects between each of the wires of the single-phase line and the three-phase circuit would be opposite and very nearly equal.

Why are gasoline and gas engines used to a greater extent than kerosene oil engines? (2) Which of the two classes is more economical in the cost of fuel? A. J. B.

Chiefly because the combustion of gas or vaporized gasoline leaves no deposit in the cylinder, while that of crude petroleum does. (2) Considering fuel cost only, the kerosene engine is probably the cheaper, but we have no recent authentic data on this subject.

What is the formula for determining the size of pulley necessary to produce a given speed, the size and speed of the pulley to which the unknown pulley is to be belted being known? (2) Does it make any difference whether the unknown pulley is the driver or the one driven? T. N. S.

Representing the known pulley diameter by D, its speed by S, the unknown diameter by D' and the speed of the unknown pulley by S', $D' = \dfrac{D\ S}{S}$. (2) No.

Can two shunt-wound dynamos be operated in series to supply a constant potential load of double the voltage of one of the machines without the use of a neutral wire? (2) How should the connections be made? W. T. K.

Yes; the two machines should be of the same maximum output. (2) Connect the armatures in series, and the shunt windings also in series, removing the connections between the junction of the shunt field windings and the two armature terminals which are connected together.

Referring to the description of the electric runabout in the January number, can the motors be made to give an aggregate of three horse-power? (2) Will they operate with a current of 25 amperes at 48 volts each? (3) Can I use wheels with 2-inch pneumatic tires instead of 2½ inches? (4) Can the bearings for the wheels be made without steel balls? (5) Can the battery jars be made of wood lined with lead sheets coated with asphalt? O. S.

No. (2) Yes; for short periods. (3) and (4) You can use any construction you like, but that specified in the article is correct. (5) No.

How can a dynamo field-magnet, or other powerful electromagnet, be disconnected from its exciting source without producing a dangerous inductive kick? G. M. S.

First connect in parallel with the winding a non-inductive resistance of about one-half the resistance of the magnet winding, and then open the switch which connects the winding to its source of current. The connections between the non-inductive resistance and the winding must, of course, be made between the winding and the switch terminals, so that when the switch is opened these connections will not be disturbed.

Why are some dynamos differentially wound, while other machines with double field windings are connected up cumulatively? (2) What would be the result of attempting to operate two differentially-wound machines in parallel? W. D. H.

A differentially-wound dynamo is a very special machine, this class of winding being used chiefly with a view to obtaining constant potential at varying speeds. Compound or cumulative windings are the standard for general service. (2) If the two machines are of exactly the same type and the speed variations are the same in both, they should work together without difficulty.

Can alternating-current generators be used for service where a ground return is used, as in the case of a street railway circuit? (2) Can a single wire and a ground return be used for alternating-current transmission? D. O.

The advisability of grounding one side of any circuit depends upon the e.m.f. of the generator and the excellence of its insulation. It is ordinarily unsafe to ground one side of a high-tension alternating-current circuit. (2) A single wire and a ground return cannot be used for any power or lighting service. The earth is not the return conductor in railway systems; the track rails serve this purpose.

Where can I obtain the transformer iron or steel necessary to construct the reactive coil described in "Electrical Designs"? (2) If this coil is used to regulate the voltage of an alternating-current circuit by varying the air-gap, will it be as wasteful as a rheostat would be on a direct-current circuit? C. T. V.

From any large dealer in iron and steel. (2) No; the loss of power in a direct-current rheostat is equal to the square of the voltage at the terminals of the rheostat divided by its resistance, whereas in a reactive coil most of the voltage at the terminals is the counter e.m.f. of the coil, which represents a negligible loss of power.

When does steam cease to be saturated and begin to be superheated? (2) How does the density of superheated steam compare with that of saturated steam? J. M. G.

As soon as the temperature of the steam is raised above that which is produced when it is evaporated. For example, the temperature of steam evaporated under a pressure of 130 pounds per square inch (absolute) is 347.1 degrees, and if it be heated above that temperature the additional heat units imparted to it are designated "superheat." (2) There is no direct relation between the two. The density of saturated steam is proportional to the 16/17th power of the absolute pressure, while that of superheated steam is proportional to the absolute pressure divided by the absolute temperature.

In testing motor-driven machines to determine the proper size of motor to use, how many watts per horse-power of rating should be taken as a criterion of armature in-put? (2) A motor operating a machine requires 44 amperes at 112 volts for starting up and 8 amperes when up to speed; after the initial inrush the current drops to the normal value of 8 amperes within six seconds; what size of motor should be used? (3) A 4-h.p. motor doing the work just described shows a pronounced spitting spark when the armature current reaches 30 amperes, but the motor has been running about two months, and shows a nice bronze gloss on the commutator; would this performance be considered admissible, or should a larger machine be used? (4) In starting loads of this character, what proportion of the maximum peak should be considered the load for which the motor should be installed? W. E. L.

Eight hundred watts per horse-power is usually sufficient allowance for the armature in-take of the machine. (2) This depends upon the overload capacity of the motor; for a machine of the best design three horse-power would be sufficient, but with a machine not so well proportioned, it would be safer to allow five. (3) Since experience shows that the sparking is not sufficient to injure the commutator, this performance might be considered admissible. (4) The safest plan is to take one-half of the maximum peak load as the rated ability of the motor; it is scarcely reasonable to expect a machine to stand more than 100 per cent momentary overload.

What is the sidewise pull of an armature core located eccentrically in a field-magnet? (2) What is the angular pull on the conductors of an armature? S. M. A.

Representing the magnetic density per square inch in the air-gap by B, the area of the pole-face in square inches by A, the displacement of the armature from the center by d, and the distance across the air-gap from pole-face to armature by g, both in fractions of an inch, the lateral pull in pounds will be equal to

$$\frac{B^2 \times A \times d \times K}{11{,}000{,}000 \times g \times k}.$$

The letters K and k represent constants, K having a value of 2 in a four-pole machine and 6 in a six-pole machine when the displacement is parallel with the axes of opposite poles. If the displacement is in the direction of a line drawn across the head of the armature midway between neighboring poles, the constant is 2.8 for a four-pole machine. The value of k ranges from 1.1 to about 1.6, according to the design of the machine. (2) The peripheral pull in pounds on each conductor is equal to

$$\frac{B^2 \times i \times L}{11{,}300{,}000}$$

In this formula i is the current in each conductor and L is the length of the armature core in inches.

RUGER GAS ENGINE.

The J. W. Ruger Manufacturing Company, of Buffalo, N. Y., has just placed on the market a new gas engine. It is of the graduated charge of throttling type, *i. e.*, the strength of the impulse is reduced by varying the quantity of the charge entering the cylinder, although the proportions of the fuel and air remain the same at all times. These engines are built in sizes from 10 to 150 horse-power, and for electric lighting work are built on the twin engine plan; that is, two engines are built side by by side, the crank shafts being coupled together by a large and heavy fly-wheel between them, making substantially a single engine of the pair. The charge enters both cylinders through one throttling valve controlled by a single governor, although each cylinder has independent mixing and exhaust valves.

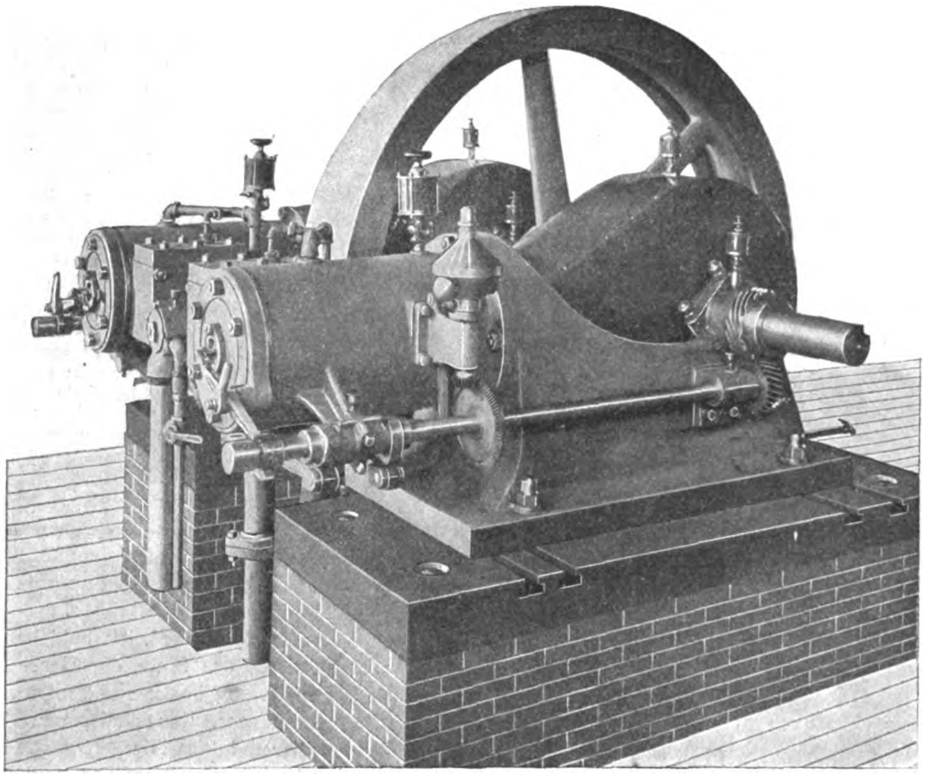


FIG. 1.—RUGER TWIN GAS ENGINE.

The valve, governor and sparker mechanism is operated by a lateral shaft running along the side of the engine and driven by a pair of spiral gears. The valves are of the poppet type, set vertically, and both the mixing valve and exhaust valve are operated mechanically. This feature of the constructure makes it unnecessary to have the extremely heavy spring usually placed on the exhaust valve to hold it closed while the engine takes a charge by suction. The valves are lifted by means of levers and cams, and are said to be so cushioned as to be practically noiseless in operation.

The governor consists of two weights hung upon a vertical shaft, the weights being enclosed in a neat and attractive bonnet. It is said to be extremely quick and sensitive in action, having positive control of the graduating valve and admitting more or less of the gas and air mixture as required by the load upon the engine. The sparker is placed in the head of the engine, and is of the well-known hammer and break type. It is operated by a reversing cam on the shaft in connection with a lever. This lever is balanced on an eccentric so arranged that the time of firing can be changed while the engine is in motion. The current for the sparker is supplied by a small generator, thus avoiding the trouble and annoyance experienced even when using the best of batteries.

The cylinders, valve chest, head, etc., are cast from a special, fine-grained, tough iron, and are supplied with a generous water jacket. The cylinder is designed with a circular flange on the engine bed. Owing to this design the expansion of the cylinder is said to be equal at all parts, and the life of the engine is claimed to be considerably longer than where flanges are placed on the sides. The cranks and connecting rods are forged from steel. Cast-iron counter-balances of such a weight as to perfectly balance the engine are fitted to the cranks.

The working parts of the engine are entirely enclosed by means of a Russia iron shield, thus keeping out the dust and preventing the throwing of oil by the counter-weights on the crank. Phosphor-bronze, babbitt metal, hardened tool steel, etc., are used for such wearing surfaces as experience has proven best adapted. All parts are easily accessible, and any parts of the engine may be reached without disconnecting other parts. At a recent test of a 20-hp. duplex engine it was demonstrated that from no load to full load the drop in speed was only 7 r.p.m., while the generator voltage varied only 1 volt, the generator being a 15-kw., compound-wound, 110-volt machine.

◆

A SMALL RESIDENTIAL PLANT.

The accompanying illustration shows a 10-h.p. Mietz & Weiss kerosene engine directly coupled to a 6½-kw. Bullock generator, which has been installed in a private residence at Bayville, L. I. The unit runs at 350 r.p.m., and is said to furnish 50 amperes at 110 volts, with a kerosene consumption of 10 pints per hour. With kerosene costing 10 cents a gallon, this would bring the cost of 100 16-c.p. lights to 10 cents, or one light at the very low figure of .001 cent per hour. The regulation is said to be within 2 per cent from no-load to full-load, and less for intermediate changes of fractional loads. The generator is connected up so as to furnish current either directly to the main line or to a Gould storage battery having an 8-hour capacity of 30 amperes. The engine is fastened to the armature of the generator by a solid clamp coupling, the manufacturer claiming that the change of angular velocity of the flywheel being reduced to a minimum, a friction or flexible coupling was not necessary. The engines are practically automatic in their operation, and can be left without attention for a considerable period; all that is necessary is to supply the oil for fuel and the lubrication. The lubrication is such that the oil is only fed to the cylinder and the crank case when the engine is in operation, the point of feed being above the oil lubricating reservoir. A small pump furnishes an exact amount of kerosene or fuel oil to the cylinder, and this is regulated by a centrifugal flywheel governor. The generator sets are manufactured in sizes from 2 to 60 horse-power by August Mietz, New York City.

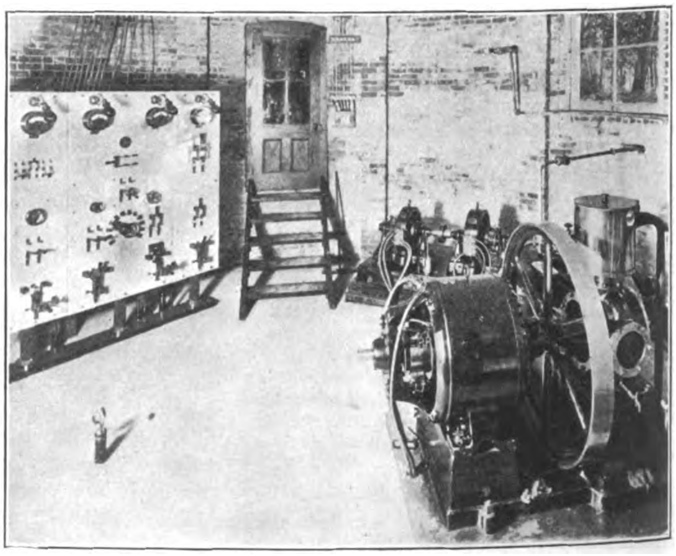


FIG. 2.—RESIDENTIAL LIGHTING PLANT.

New Apparatus and Appliances

TESTING SET FOR ALTERNATING-CURRENT WATTMETERS.

Fig. 1 herewith, shows a testing set brought out by the Sangamo Electric Company, of Springfield, Ill., for testing alternating-current wattmeters either in the station or on the consumer's premises, being designed for use on the standard indicating or integrating wattmeter, and when convenient, a standard voltmeter. The purpose of the set is to give a wide range of loads under absolute control with a very small actual expenditure of energy for apparent heavy loads, these being obtained by means of a small transformer within a box of new and peculiar construction. For light loads, up to 120 or 150 watts, a set of non-inductive resistances and a small water rheostat are provided, all carried inside of the box; each resistance set being standardized for a certain wattage at any desired voltage. Fig. 2 shows a diagram of connections. The water rheostat is on a third snap switch, and is operated by means of a fibre knob near the front of the box. This rheostat is composed of a heavy glass jar filled with water and made water-tight by rubber gaskets where the brass operating rod passes into it, the rod being moved vertically by the fibre knob to get any desired load within the range of the rheostat, which is about 5 to 30 watts. On the switch-plate of the set are the three indicating snap switches for the light loads, the various binding posts, the rheostat knob and a double-pole, double-throw switch. For light loads this switch is set in the position marked "light," all connections being then made so that the resistances and rheostat are an actual non-inductive load on the meter tested, the special transformer not being in circuit. For heavy loads, above 200 watts, the switch is thrown over to the position marked "heavy," changing ten connections to the various parts of the apparatus. The primary of the small transformer is now in series with the standard resistance and rheostat, which thus become simple controllers for varying the pressure on the primary, giving a range of impressed e.m.f from a few volts to the full-line pressure. The secondary transformer is wound for two or three volts maximum and of large capacity, and is at the same time connected directly to the series coils of the meter and standard wattmeter. These being of very low resistance, the full-load current will flow at from ½ to 1 volt pressure, according to the type of meter under test. Therefore, by varying the primary voltage on the transformer the secondary voltage and current may be varied as desired. The full-line e.m.f. is kept on the shunt coils of the meter under test and the standard in both positions of the switch, and as phase relations are said to be maintained correct by the special construction of the transformer, apparently large loads are obtained with the switch in the "heavy" position with actually less power, so it is claimed, than is used for resistances on light loads. For inductive load, binding posts are provided for connecting an arc lamp, motor or reactance coil, the main switch being set in the "light" position, as the actual load must be used for this purpose. To facilitate the inspection of the water rheostat, the switch-plate is hinged at the back, being held in front by three knurled screws, which, when removed, allow the plate to be swung back without disturbing any connections. The various binding posts are marked with small plates near them, and the only part of the apparatus which needs attention is the water rheostat, which should be inspected occasionally to see that it is full enough, and that the rod is fairly clean.

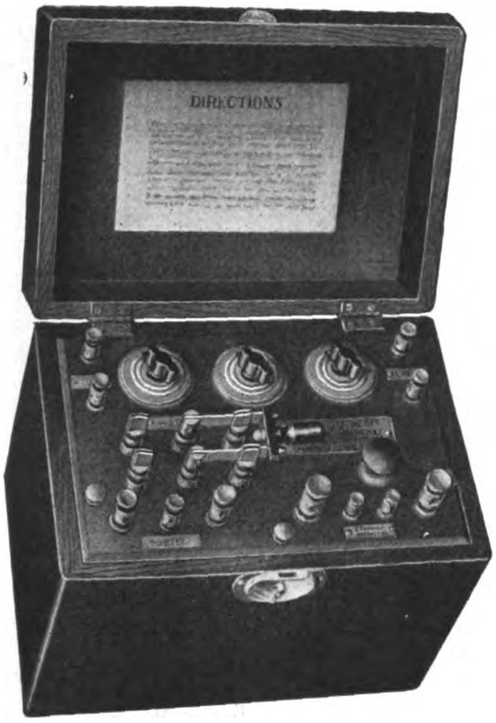


FIG. 1.—SANGAMO TESTING SET.

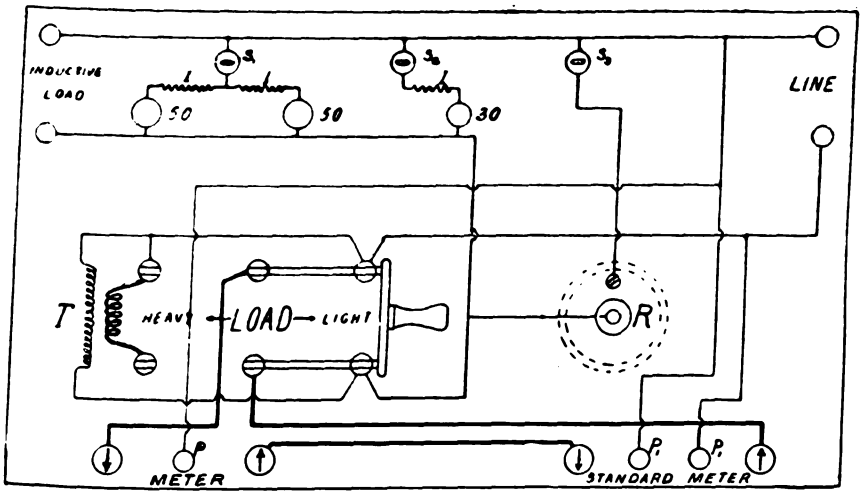


FIG. 2.—DIAGRAM OF CONNECTIONS.

COMBINED SNAP SWITCH AND CUT-OUT.

Something entirely new among electrical devices and one which will doubtless be appreciated by electrical contractors and wiremen has been brought out by the Hart & Hegeman Manufacturing Company, of Hartford, Conn., and is illustrated by Fig. 3 herewith. This consists of a standard double-pole switch mounted on a suitable porcelain base in connection with two cartridge fuses, all encased under one cover. The terminal clips in which the supply wires are placed are outside the cover. The switch is furnished either with or without the fuses, and it will be found advantageous to control and protect motors, arc lamps and incandescent lamp circuits; it will also be found convenient for use as a service switch on small installations and for panel-board work. In factories and mills and for general work, where switches and cut-outs cannot be readily centralized, its use will be most economical, effecting a saving in wire and the cabinets.

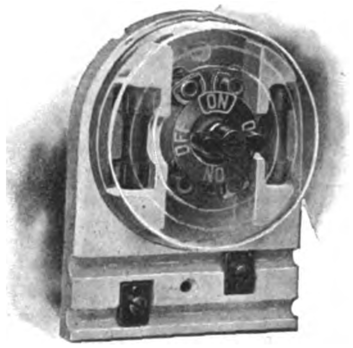


FIG. 3.—SNAP SWITCH AND CUT-OUT.

NEW MAGNETO TELEPHONE.

Fig. 4 herewith shows an interior view of a new magneto telephone brought out by the Vought-Berger Company, of La Crosse, Wis., and designated by them "Number Forty-five." This is equipped with a Bell type solid-back long-distance transmitter mounted on a hollow adjustable arm with a double concealed cord; bipolar receiver with concealed cord connections, silk-wound long-distance induction coil, and a long lever hook switch. The telephones are equipped with either a three or four-bar series generator or a four or five-bar bridging generator. All binding posts are concealed and no bare wires are used. The ringer striker is protected by a nickel-plated guard. A combined saw-toothed plate and carbon block lightning arrester is used. The swing-down shelf makes the ringers readily accessible for inspection and adjustment, it being possible to view both the gong side and the coil side simultaneously. The batteries are placed in a compartment in the lower portion of the cabinet and are covered by a sliding panel. They can be reached without opening the balance of the telephone. All working parts can be inspected both from the front and the top. The maker claims that it is but a simple matter to change the telephone from series magneto to bridging, or *vice versa*, as either generator will fit the cabinet.

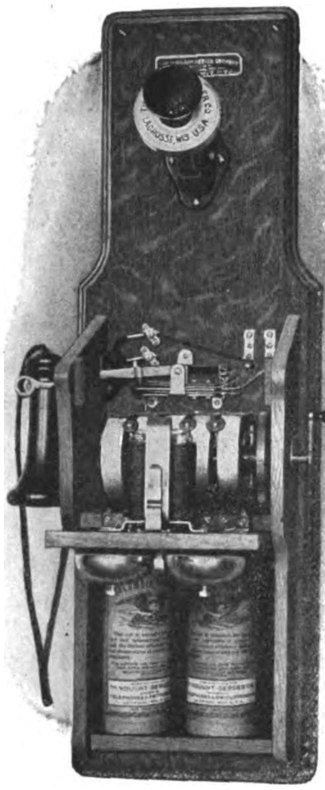


FIG. 4.—VOUGHT-BERGER TELEPHONE.

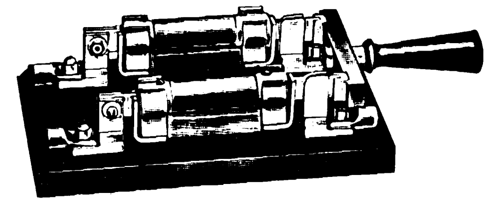


FIG. 5.—IDEAL FUSE SWITCH.

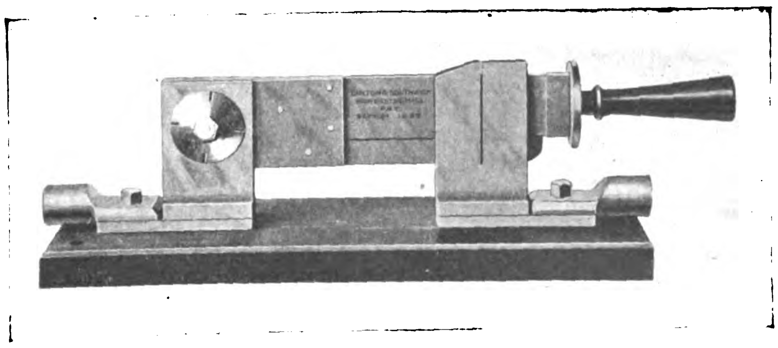


FIG. 6.—MONARCH QUICK-BREAK SWITCH.

THE "P. B. H." GAUGE COCK.

Fig. 7 herewith shows a quick-opening, self-closing, weighted gauge cock brought out by P. B. Huyette, of Philadelphia, Pa. The valve pencil of the cock is made of a specially prepared metal which is said to insure a leakless gauge cock under high pressures. This pencil is over three-quarters of an inch in length, and when completely worn can be quickly replaced by a new one at a trifling cost; provision being made for ejecting the short piece of worn pencil through a hole ⅛ in. in diameter. It will be noted that the arrangement for the utilizing of the valve pencil for over its entire length of three-quarters of an inch affords a cock which for long periods needs no repairing other than occasional adjustments of the weight as the pencil wears away. This adjustment is made by unscrewing the nut and slightly raising the weight, which is then secured in its new position by tightening the nut.

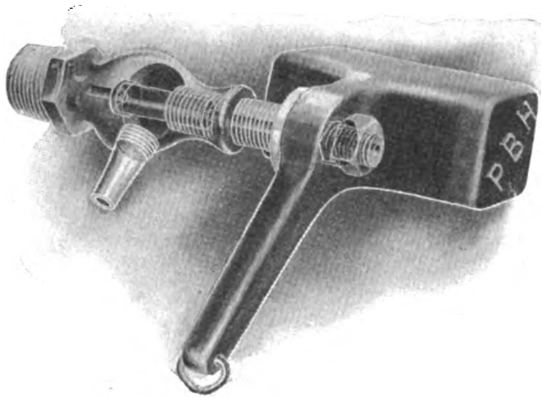


FIG. 7.—"P. B. H." GAUGE COCK.

LINTON AND SOUTHWICK SWITCHES.

Fig. 5 herewith shows the "Ideal" fuse switch made by Linton & Southwick, of Worcester, Mass. The special feature of the switch is the absence of the usual knife blades and the consequent economy of space. The fuse takes the place of the knife blade and thus reduces the length of the switch by a length equivalent to that of the knife blade. The switch is made with single, double or triple-pole, and with single or double-throw. The "Monarch" quick-break switch made by the same concern is shown by Fig. 6. In this switch the spring which operates the auxiliary knife blade is entirely concealed, thus making the switch neat and attractive in appearance.

WHITE STAR LAMP.

The Standard Electrical Manufacturing Company, of Niles, Ohio, has added a novelty to their practically complete line of incandescent lamps. This novelty is called by them the "White Star" lamp. This is a globular incandescent lamp of 2½ inches diameter, made in 4, 8 and 16-c.p. sizes, as ordinarily rated. Porcelain petticoat shades of different designs are supplied with the lamp. The white shades are supplied in two types—the plain white and the fluted white, the latter being shown by Fig. 8. Shades may be also had of green and red porcelain lined with white. The diffusion of light from this lamp is said to be very pleasing, and the so-called downward light is claimed to be increased about 50 per cent. Although especially adapted for decorative work, the lamps are said to be coming into very common use for general illumination.

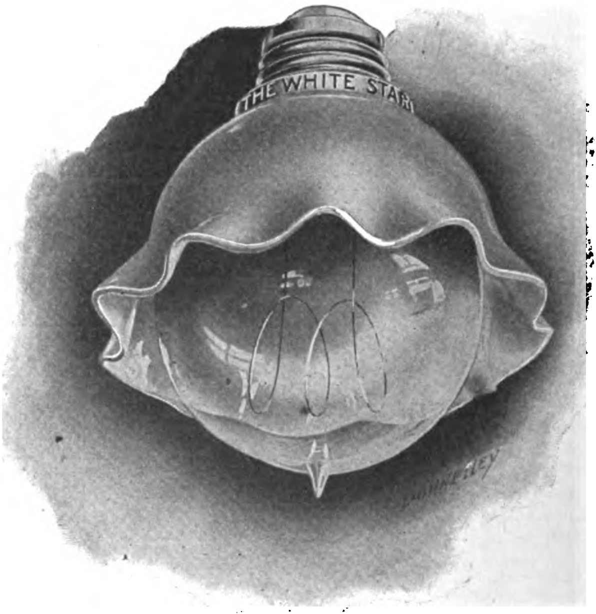


FIG. 8.—WHITE STAR INCANDESCENT LAMP.

IRON BOX TELEPHONES.

Fig. 9 herewith shows a telephone outfit especially designed by the Couch & Seeley Company, of Boston, Mass., for street railway work. It consists of a very heavy iron box containing a complete telephone with a very powerful signalling equipment. The instruments are made weather-proof and practically damage-proof. When the door is closed it engages with a pin marked *A*, and disconnects the entire apparatus from both sides of the line. This not only prevents burnouts from lightning and crossing of line wires, but permits of a large number of stations being put on one pair of line wires. as only the station in use is connected across the line at any time. The microtelephone has been found to be peculiarly well adapted for this particular work. It allows the boxes to be supported a good distance from the ground, and at the same time permits of the use of the telephone by either short or tall people with equal convenience. The peculiar construction of the instrument, of course, compels the person using it to speak directly into the mouth-piece, which insures good transmission.

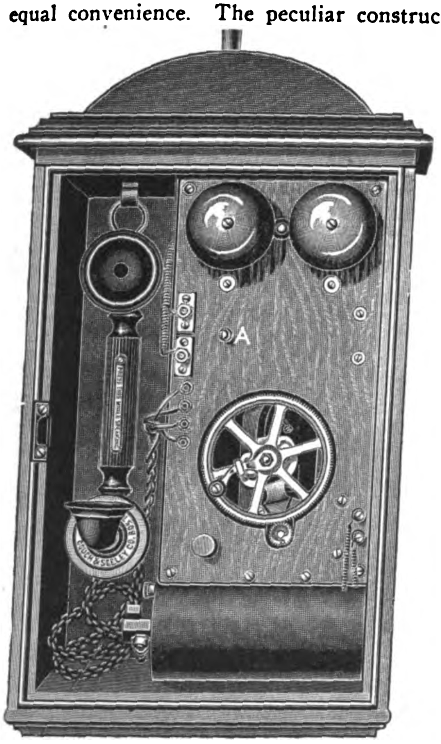


FIG. 9.—IRON BOX TELEPHONE.

PORTABLE AND DESK LAMPS.

McLeod, Ward & Co., of New York, patentees and manufacturers of the Kinsman desk lamp specialties have introduced a number of modifications and improvements in this line of work, two of which are here illustrated. The Kinsman portable for use on a bookkeeper's desk, shown in Fig. 10, can, of course, be used in any place where an elevated fixture of the kind is required. It is arranged to clamp on the gallery of a bookkeeper's desk, and is adjustable in every way. It is made in polished brass, nickel-plate, old brass or oxidized copper. The Ward typewriter's desk lamp is shown by Fig. 11. The supporting arm is adjustable, as is also the opening of the reflector, so that the fixture can be arranged to throw all of the light on the typewriter.

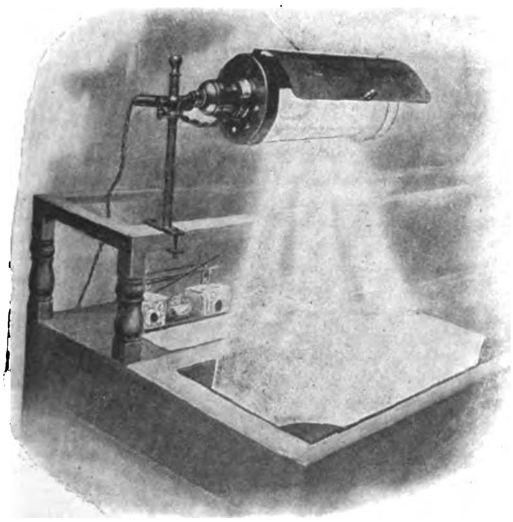


FIG. 10.—KINSMAN BOOKKEEPER'S DESK LAMP.

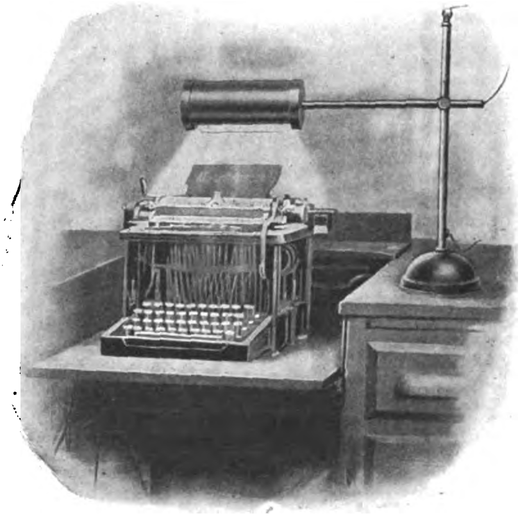


FIG. 11.—WARD TYPEWRITER'S DESK LAMP.

NEW BOOKS.

THE AMERICAN STEEL WORKER. A Twenty-Five Years' Experience in the Selection, Annealing, Working, Hardening and Tempering of Various Kinds and Grades of Steel. By E. R. Markham. First Edition. New York: The Derby-Collard Company, 1903. 343 pages, 5⅜ x 7¾; 160 illustrations. Price, $2.50.

On reading a little way in this book, it becomes apparent to any one who is himself at all familiar with steel that the author has had a vast experience in the matters of which he writes. The book is practical; not in the sense of being non-theoretical, for the author gives as much theory as is necessary for the intelligent understanding of the operations and processes, but in the sense that it is closely connected with shop practice. The reader is impressed with the belief that the author has done every one of the things he tells about many times, and not, as is so often the case, that he has done some of them and copied the information about the rest from other sources in order to make a respectable-sized book.

The mechanical make-up of the volume is not prepossessing; there is a cheap showiness about it that is not in keeping with the solid merit of the contents. The literary style is for the most part direct and perspicuous; the writer not having attempted any flights of rhetoric, avoids the literary pit-falls in which some of the contemporary writers on allied subjects have become entangled. There is a good deal of repetition or reiteration of certain things throughout the whole book, which might be adversely criticised, but the author states that this is intentional. The principle on which this is done is that some facts cannot be too strongly impressed upon the steel worker, and considering the fact that a large portion of the readers will not, in all probability, read the book systematically, but will only look up the particular subject in which they are at that moment interested, the principle is wisely chosen.

Whatever minor defects the book may have, it certainly has the great merit that it is full of reliable information about steel: information of the most practical kind, and in a shape that renders it available to the practical steel worker.

STUDENTS' GUIDE TO SUBMARINE CABLE TESTING. By H. K. C. Fisher and J. C. H. Darby. Third (Enlarged) Edition. New York: D. Van Nostrand Company. Cloth; 236 + viii pages, 5¼ ins. x 8½ ins.; illustrated. Price, $2.50.

This volume is one of the deservedly well known London *Electrician* Series. The authors frankly disclaim originality, in the sense of new tests or tests not elsewhere published, but claim to have presented the subject in a simple and clear manner. The first preface states, "The scope of the present work is bounded by the requirements of the Electrical Examinations for Supervisors, and the ordinary electrical outfit of all the (Eastern Extension Telegraph) company's stations. The Thomson "mixture" method for capacity has been omitted because it requires a special key, not found in that outfit, although the authors consider it, next to the Gott method, the best." On page 19 is a diagram of the Ayrton and Mather universal shunt, and on the succeeding page a description that is intended to fit the diagram, but there is a discrepancy of lettering that runs through the whole description. The part of the resistance in shunt with the galvanometer is said to be in series and *vice versa.* "The wire from the battery key," so says the description, "is connected to the index or slider and the line wire to the galvanometer." The diagram shows these two connections transposed. The authors state in the first preface that some of their critics remarked that there were "too many *X's* and *Y's*" in their original pamphlet. The authors themselves say, "We think it a great pity that the fact is not realized that an hour or so a day for two of three months devoted to the study of algebra would be sufficient to enable a man to read and understand most articles on testing." With this sentiment we heartily concur. We have heard of "astronomy without mathematics," but we never investigated it; the name was sufficient. Cable testing without elementary algebra is in the same category. We advise the student either to learn simple algebra or to give up the idea of becoming a cable tester. This book is recommended as an excellent elementary work on the subject. The publishers are open to criticism for omitting the date of publication, but as it happens this does not affect the value of the present book, for the reason that it is obviously of recent origin.

CURRENT DENSITIES IN STANDARD WIRES

It often occurs that one wishes very much to know the number of amperes corresponding to a certain density in amperes per square inch of cross-section for a standard gauge number of copper wire, but that this information is not of sufficient importance to impel one to make the necessary calculation. This is true more particularly in cases involving a comparison of several densities or wire sizes in order to obtain a sort of criterion for purposes of selection. The accompanying table (divided into two sections for convenience in pasting in a pocket-book or small scrap-book) will doubtless be welcome to those having work to do that involves such cases.

TABLE I.

Numbers in body of table are Amperes corresponding to the Densities in the left-hand column.

Amperes per sq. in.	Wire Sizes; B. & S. Gauge.										
	2	3	4	5	6	7	8	9	10	11	12
500	26.0	20.6	16.4	13.0	10.3	8.17	6.48	5.14	4.07	3.23	2.56
550	28.6	22.7	18.0	14.3	11.3	8.99	7.12	5.65	4.48	3.55	2.82
600	31.2	24.8	19.6	15.6	12.3	9.81	7.78	6.17	4.89	3.88	3.07
650	33.8	26.8	21.3	16.9	13.4	10.63	8.43	6.68	5.3	4.2	3.33
700	36.5	28.9	22.9	18.2	14.4	11.44	9.08	7.19	5.7	4.52	3.59
750	39.1	31.0	24.5	19.5	15.4	12.26	9.72	7.71	6.11	4.85	3.84
800	41.7	33.0	26.2	20.8	16.5	13.08	10.37	8.22	6.52	5.17	4.1
850	44.3	35.1	27.8	22.1	17.5	13.9	11.02	8.74	6.93	5.49	4.35
900	46.9	37.2	29.5	23.4	18.5	14.71	11.67	9.25	7.34	5.82	4.61
950	49.5	39.2	31.1	24.7	19.5	15.53	12.32	9.76	7.74	6.14	4.87
1000	52.1	41.3	32.8	26.0	20.6	16.35	12.96	10.28	8.15	6.46	5.12
1050	54.7	43.4	34.4	27.3	21.6	17.16	13.61	10.79	8.56	6.79	5.38
1100	57.3	45.4	36.0	28.6	22.6	17.98	14.26	11.3	8.97	7.11	5.64
1150	59.9	47.5	37.7	29.9	23.7	18.8	14.91	11.82	9.37	7.43	5.89
1200	62.5	49.6	39.3	31.2	24.7	19.62	15.56	12.33	9.78	7.76	6.15
1250	65.1	51.6	40.9	32.5	25.7	20.43	16.21	12.85	10.19	8.08	6.41
1300	67.7	53.7	42.6	33.8	26.8	21.25	16.86	13.36	10.6	8.4	6.66
1350	70.4	55.8	44.2	35.1	27.8	22.07	17.51	13.87	11.01	8.73	6.92
1400	73.0	57.8	45.9	36.4	28.8	22.9	18.15	14.39	11.41	9.05	7.18
1450	75.6	59.9	47.5	37.7	29.9	23.7	18.8	14.9	11.82	9.37	7.43
1500	78.2	62.0	49.1	39.0	30.9	24.52	19.47	15.42	12.23	9.7	7.69
1550	80.8	64.0	50.8	40.3	31.9	25.34	20.1	15.93	12.64	10.02	7.95
1600	83.4	66.1	52.4	41.6	33.0	26.15	20.75	16.44	13.04	10.33	8.2
1650	86.0	68.2	54.1	42.9	34.0	26.97	21.39	16.96	13.45	10.67	8.46
1700	88.6	70.2	55.7	44.2	35.0	27.80	22.04	17.48	13.86	10.99	8.71
1750	91.2	72.3	57.3	45.5	36.1	28.61	22.69	17.99	14.27	11.31	8.97
1800	93.8	74.4	59.0	46.8	37.1	29.43	23.34	18.5	14.68	11.64	9.23
1850	96.4	76.4	60.6	48.1	38.1	30.25	23.99	19.02	15.08	11.96	9.48
1900	99.0	78.5	62.2	49.4	39.1	31.06	24.64	19.53	15.49	12.28	9.74
1950	101.6	80.6	63.9	50.7	40.2	31.88	25.29	20.05	15.9	12.61	10.0
2000	104.3	82.6	65.5	52.0	41.2	32.7	25.94	20.56	16.31	12.93	10.26
2100	109.5	86.8	68.8	54.6	43.3	34.33	27.23	21.59	17.12	13.58	10.77
2200	114.7	90.9	72.1	57.2	45.3	35.97	28.54	22.62	17.94	14.22	11.28
2300	119.9	95.0	75.4	59.8	47.4	37.6	29.83	23.65	18.75	14.87	11.79
2400	125.1	99.2	78.6	62.4	49.5	39.24	31.12	24.67	19.57	15.52	12.31
2500	130.3	103.3	81.9	65.0	51.5	40.87	32.42	25.7	20.39	16.17	12.82
2600	135.5	107.5	85.2	67.6	53.6	42.51	33.71	26.73	21.2	16.81	13.33
2700	140.7	111.6	88.5	70.2	55.6	44.14	35.01	27.76	22.02	17.46	13.85
2800	146.0	115.7	91.8	72.8	57.7	45.78	36.31	28.79	22.83	18.1	14.36
2900	151.2	119.8	95.0	75.4	59.8	47.41	37.6	29.82	23.65	18.75	14.87
3000	156.4	124.0	98.3	78.0	61.8	49.05	38.9	30.84	24.46	19.4	15.38

TABLE I-a.

Numbers in the body of the table are the Amperes corresponding to the Densities in the left-hand column.

Amperes per sq. in.	Wire Sizes; B. & S. Gauge.												
	13	14	15	16	17	18	19	20	21	22	23	24	25
500	2.03	1.61	1.27	1.01	.8	.63	.5	.4	.31	.25	.2	.15	.126
550	2.23	1.77	1.4	1.11	.88	.7	.55	.44	.35	.27	.22	.17	.138
600	2.44	1.93	1.53	1.21	.96	.76	.6	.48	.38	.3	.24	.19	.151
650	2.64	2.09	1.66	1.31	1.04	.82	.65	.52	.41	.33	.26	.2	.163
700	2.84	2.25	1.79	1.42	1.12	.89	.7	.56	.44	.35	.28	.22	.176
750	3.05	2.41	1.91	1.52	1.2	.95	.75	.6	.47	.38	.3	.24	.188
800	3.25	2.58	2.04	1.62	1.28	1.02	.8	.64	.51	.4	.32	.25	.201
850	3.45	2.74	2.17	1.72	1.36	1.08	.86	.68	.54	.43	.34	.27	.214
900	3.66	2.9	2.3	1.82	1.44	1.14	.91	.72	.57	.45	.36	.28	.226
950	3.86	3.06	2.43	1.92	1.52	1.21	.97	.76	.6	.48	.38	.3	.239
1000	4.06	3.22	2.55	2.02	1.6	1.27	1.01	.8	.63	.5	.4	.31	.251
1050	4.27	3.38	2.68	2.13	1.68	1.34	1.06	.84	.67	.53	.42	.33	.264
1100	4.47	3.54	2.81	2.23	1.77	1.4	1.11	.88	.7	.55	.44	.35	.277
1150	4.67	3.7	2.94	2.33	1.85	1.46	1.16	.92	.73	.58	.46	.36	.289
1200	4.88	3.87	3.07	2.43	1.93	1.53	1.21	.96	.76	.6	.48	.38	.302
1250	5.08	4.03	3.19	2.53	2.01	1.59	1.26	1.0	.79	.63	.5	.39	.314
1300	5.28	4.19	3.32	2.63	2.09	1.65	1.31	1.04	.82	.65	.52	.41	.327
1350	5.49	4.35	3.45	2.73	2.17	1.72	1.36	1.08	.86	.68	.54	.42	.339
1400	5.69	4.51	3.58	2.84	2.25	1.78	1.41	1.12	.89	.7	.56	.44	.352
1450	5.89	4.67	3.7	2.94	2.33	1.85	1.46	1.16	.92	.73	.58	.46	.365
1500	6.1	4.83	3.83	3.04	2.41	1.91	1.51	1.2	.95	.75	.6	.47	.377
1550	6.3	4.99	3.96	3.14	2.49	1.97	1.56	1.24	.98	.78	.62	.49	.39
1600	6.5	5.16	4.09	3.24	2.57	2.04	1.61	1.28	1.02	.8	.64	.5	.402
1650	6.71	5.32	4.22	3.34	2.65	2.1	1.67	1.32	1.05	.83	.66	.52	.415
1700	6.91	5.48	4.34	3.44	2.73	2.16	1.72	1.36	1.08	.85	.68	.54	.428
1750	7.11	5.64	4.47	3.55	2.81	2.23	1.77	1.4	1.11	.88	.7	.55	.44
1800	7.32	5.8	4.6	3.65	2.89	2.29	1.82	1.44	1.14	.91	.72	.57	.453
1850	7.52	5.96	4.73	3.75	2.97	2.36	1.87	1.48	1.17	.93	.74	.58	.465
1900	7.72	6.12	4.86	3.85	3.05	2.42	1.92	1.52	1.21	.96	.76	.6	.478
1950	7.93	6.28	4.98	3.95	3.13	2.48	1.97	1.56	1.24	.98	.78	.61	.491
2000	8.13	6.45	5.11	4.05	3.21	2.55	2.02	1.6	1.27	1.01	.8	.63	.503
2100	8.54	6.77	5.37	4.26	3.38	2.68	2.12	1.68	1.33	1.06	.84	.66	.528
2200	8.94	7.09	5.62	4.46	3.54	2.8	2.22	1.76	1.4	1.11	.88	.7	.553
2300	9.35	7.41	5.88	4.66	3.7	2.93	2.32	1.84	1.46	1.16	.92	.73	.58
2400	9.76	7.74	6.14	4.87	3.86	3.06	2.42	1.92	1.52	1.21	.96	.76	.604
2500	10.16	8.06	6.39	5.07	4.02	3.19	2.53	2.0	1.59	1.26	1.0	.79	.629
2600	10.57	8.38	6.65	5.27	4.18	3.31	2.63	2.08	1.65	1.31	1.04	.82	.654
2700	10.98	8.71	6.9	5.48	4.34	3.44	2.73	2.16	1.72	1.36	1.08	.85	.68
2800	11.38	9.03	7.16	5.68	4.5	3.57	2.83	2.24	1.78	1.41	1.12	.89	.705
2900	11.79	9.35	7.41	5.88	4.66	3.7	2.93	2.32	1.84	1.46	1.16	.92	73
3000	12.2	9.67	7.67	6.08	4.82	3.82	3.03	2.4	1.91	1.51	1.2	.95	.755

American Street Railway Convention Notes.

The Magnet Wire Company, of New York, was represented by G. F. Valentine.

The Garton-Daniels Company, of Keokuk, Ia., was represented by J. V. E. Titus.

The Buckeye Electric Company, of Cleveland, was represented by W. R. Bonham.

J. G. White & Company, of New York and London, were represented by J. G. White.

"Okonite" was adequately represented by George T. Manson, of the New York office.

The Standard Varnish Company, of New York, sent as its representative J. C. Dolph.

John A. Roebling's Sons Company, of Trenton, N. J., had Ulysses G. Tingley in attendance.

The Western Electric Company was represented by R. M. Campbell and R. H. Harper.

N. A. Christensen, of Milwaukee, manufacturer of air compressors, was represented by J. E. Eldred.

The American Electrical Works, Providence, R. I., was represented by its New York sales agent, W. J. Watson.

The Massachusetts Chemical Company, of Boston, distributed a unique souvenir in the shape of a rubber cuspidor mat.

G. M. Gest, conduit contractor and designer, of New York, sent his Cincinnati representative, W. T. Jackson, to the convention.

T. G. Seixas, of the Philadelphia Electric Company, was a guest at the convention of the American Street Railway Association.

The McRoy Clay Works, Brazil, Ind., was represented by E. F. Kirkpatrick and had signs everywhere about the grounds.

Merritt & Company, of Philadelphia, makers of the expanded metal lockers, had some of these on exhibit in charge of J. E. Morgan.

The American Steel & Wire Company made no exhibit, but were ably represented by H. G. Greenburg, C. S. Knight, Jr., and F. A. Keys.

The Bryan Marsh Company, manufacturers of incandescent lamps, was ably represented by Guy V. Williams, manager of the New York office.

The Stuart-Howland Company, of Boston, Mass., made an elaborate exhibit of its specialties. H. W. Smith and H. De Steese looked after the exhibit.

The Electric Motor & Equipment Company, of Newark, N. J., had a telling exhibit in many electric signs which were in evidence at the convention.

The Standard Paint Company, of New York, manufacturers of the P. & B. products, was represented by F. F. Van de Water, Charles Ernshaw and N. D. King.

The Allis-Chalmers Company, of Chicago and Milwaukee, had no exhibit, but was represented by John B. Allan, Jesse Vail, James Lyons and Edward J. Meisenheimer.

The Chase-Shawmut Company's exhibit was in charge of C. J. Harington, who showed a full line of Shawmut soldered rail bonds attached to all makes of rail joints.

S. B. Condit, Jr. & Company, Boston, Mass., were represented by S. B. Condit, Jr. The company distributed a very handsome souvenir in the shape of a pocket knife.

"Habirshaw" wire and cable interests were well taken care of by Dr. W. M. Habirshaw, of the India Rubber & Gutta Percha Insulating Company, as well as by J. B. Olsen.

The Electric Cable Joint & Appliance Company, New York, distributed a neat folder describing its electric cable joint. The company was represented by W. M. Murphy.

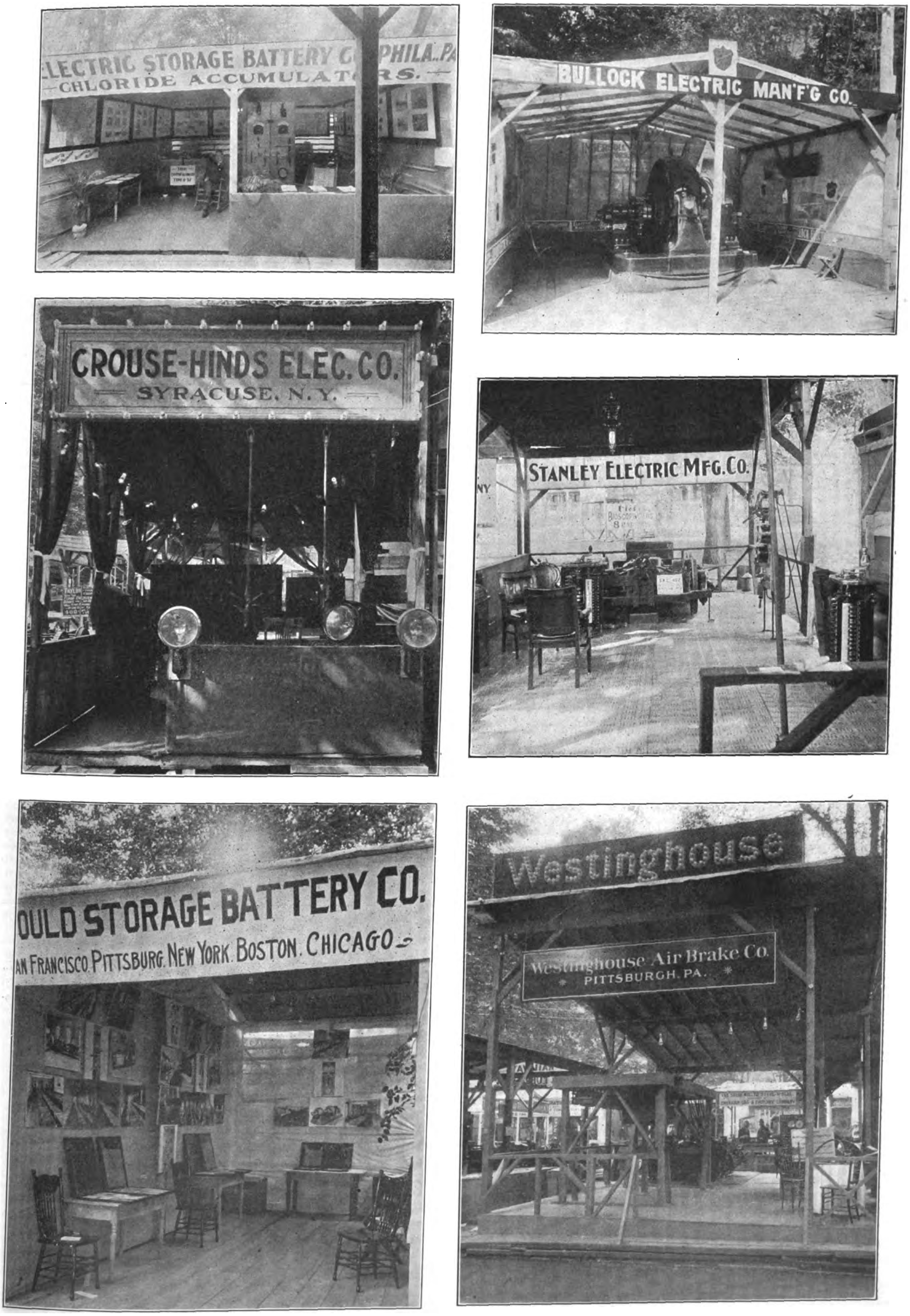
National Carbon Company, of Cleveland, exhibited its well-known Columbia dry cells for automobile purposes. The exhibit was in charge of N. C. Cotabish and R. K. Mickey.

The Le Valley Vitae Carbon Brush Company, of New York, was represented by J. V. Clarke, W. H. Ball and L. Clarke. The company gave away a sample set of carbon brushes.

The Standard Vitrified Conduit Company exhibited single and multiple-duct vitrified conduit and third-rail insulators, in charge of W. H. Barnard. D. S. Barnard, president of the company, was also in attendance.

The D. & W. Fuse Company, Providence, R. I., had W. S. Sisson on hand to meet the trade and agents of this company from various parts of the country.

The Banner Electric Company, of Youngstown, Ohio, exhibited a line of lamps, a feature being a special series burning lamp for electric railway service.


ELECTRIC STORAGE BATTERY CO. PHILA., PA
CHLORIDE ACCUMULATORS.
BULLOCK ELECTRIC MAN'F'G CO.
CROUSE-HINDS ELEC. CO.
SYRACUSE, N.Y.
STANLEY ELECTRIC MFG. CO.
OULD STORAGE BATTERY CO.
AN FRANCISCO. PITTSBURG. NEW YORK. BOSTON. CHICAGO
Westinghouse
Westinghouse Air Brake Co.
PITTSBURGH, PA.

GROUP OF EXHIBITS AT THE CONVENTION OF THE AMERICAN STREET RAILWAY ASSOCIATION.

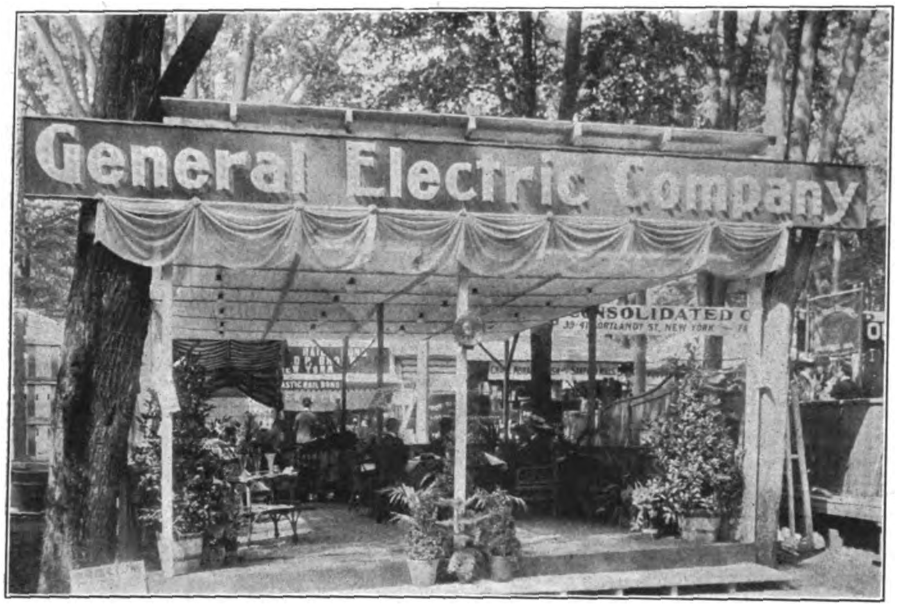
Francis Granger, of New York, representing the Sterling Electrical Manufacturing Company, and other specialties which he handles, was very much in evidence at the convention.

The Standard Underground Cable Company had its usual display of cable samples and was represented by C. J. Marsh, T. E. Hughes, J. E. Pietzcker, F. C. Crosby, T. J. McBride and Mr. Kimball.

The Gold Car Heating & Lighting Company, of New York, had a full line of electric car heaters on exhibition. The representatives of this company at the convention were E. E. Gold, J. E. Ward, W. H. Stocks and Frank Cahill.

The Dearborn Drug & Chemical Company, of Chicago, was represented by William McVicker, J. Johnson and G. W. Spier, who presented the merits of the various compounds manufactured by the company for obviating boiler flue troubles.

Crocker-Wheeler Company, Ampere, N. J., distributed a special bulletin of street railway generators and gave away handsome souvenir match safes. C. W. Startsman, F. B. De Gress, S. Russell and R. N. C. Barnes represented the company.



HEADQUARTERS OF THE GENERAL ELECTRIC COMPANY.

The Franklin Rolling Mill & Foundry Company, Franklin, Pa., manufacturer of the tripartite steel pole, had one of these three-part street poles on exhibition. G. V. A. Conger, superintendent of the pole department, was in charge of the exhibit.

The Elliott Brothers Electric Company, of Cleveland, had an attractive exhibit in charge of W. H. Elliott, who explained his company's facilities for handling dynamo and motor repairs, including armature and field rewinding, commutator building, etc.

The American Diesel Engine Company, of New York, manufacturers of the Diesel oil engine, was represented at the convention by Norman McCarty. A prominent sign was also displayed containing a list of representative plants now using the Diesel engines.

The Sterling Varnish Company, and the Pittsburg Insulating Company, of Pittsburg, were represented by H. Lee Bragg and S. C. Schenck. They showed samples of varnish, armature coils coated with varnish, insulating varnish, and a new black plastic varnish for coil work.

Eugene Munsell & Company and the Mica Insulator Company, of New York and Chicago, were represented by Charles E. Colman. They exhibited micanite rings, segments, and empire cloth and their other lines of insulation. Samples of their material were freely distributed among the visiting delegates.

The Electric Storage Battery Company, of Philadelphia, had a very plain yet effective exhibit consisting of two chloride Type G-51 cells having a capacity of 2000 amperes and two Type F-11 cells of 200-ampere capacity. The representatives present were Charles Blizard, J. L. Woodbridge, A. Taylor, G. H. Atkins, F. J. Stone and H. B. Gay.

The Robins Conveying Belt Company, of New York, had in operation on the grounds a complete model outfit of Robins conveyors as they would be in a large power house, including the Richardson automatic scales. Some photographs of recent installations of Robins conveyors were shown by A. B. Proal, Jr., and John Fuller.

Rossiter, MacGovern & Company had a large space on the lawn fitted up with a booth and replete with electrical apparatus. The company also occupied one of the small cottages in the Annex, where a hospitable welcome was extended to all comers. Frank MacGovern, R. J. Randolph, J. A. Pierce, C. J. MacDonald and J. W. Archer were in attendance.

The Benjamin Electric Manufacturing Company, of Chicago, had an attractive display of clusters of lamps arranged with the Benjamin wireless cluster. In the exhibit were shown the styles adopted by the Interborough Company, of New York, for all its cars, and a series two-light cluster, as well as the five-light series clusters used by the New York Metropolitan in its car-barns.

The Gould Storage Battery Company, of New York, had on exhibition plates of the Gould Storage battery. Their booth was attractively decorated with photographs of some of the many large installations in street railways which it has recently made in various parts of the United States. The company was represented at the convention by W. W. Donaldson and E. L. Draffen.

Bullock Electric Manufacturing Company, of Cincinnati, had the largest single electrical exhibit at the convention. This was one of five rotaries made for the Scioto Valley Railway Company's power plant at Columbus, Ohio. This receives three-phase current and delivers 400-kw direct-current at 600 volts. The exhibit was in charge of R. T. Lozier, G. B. Foster, W. S. Arnold, A. E. Foote and C. Van Deventer.

The Pittsburg Reduction Company, of Pittsburg, had a unique display. The booth was a large one and one-half of it was occupied by an aluminum wire drawing machine in operation, reducing wire from No. 2 gauge to No. 9 gauge. Aluminum splices, cables, and insulated and bare wire were exhibited. Arthur W. Davis, A. K. Laurie, J. A. Rutherford, Cyrus Harris, S. K. Colby, W. R. Darby, E. H. Noyse, William Hoopes and J. H. Finney were in attendance.

F. Locke, of Victor, N. Y., associated with Archbold-Brady Company, of Syracuse, had a striking and effective display of high-potential porcelain insulators. A separate dark room had been fitted up containing a high-potential transformer capable of giving a potential of 175,000 volts, and with it over 100,000 volts were thrown on groups of porcelain and glass insulators to show how they could stand up under the enormous strain. Mr. Locke was present to explain the resisting powers of his insulators.

The Crouse-Hinds Electric Company, of Syracuse, N. Y., exhibited the Crouse-Hinds arc headlight, junction boxes, switchboards, switches and Nesbit specialties. Those present were A. F. Hills, Nathan Shute and H. B. Crouse. A very notable exhibit at the convention was the decoration of the pagoda of the Grand Union Hotel with miniature electric lamps, strung on Norbitt porcelain socket attachments. The lamps were surrounded by red decorative paper and strung in a very artistic way, making a brilliant and attractive effect.

The National Electric Company, successor to The Christensen Engineering Company, was represented by a large corps of salesmen and engineers. It showed an air-brake equipment on the exhibit grounds and entertained in a nearby suite of rooms in the Grand Union Hotel. F. C. Randall, general manager of sales, was assisted by J. H. Denton, J. T. Cunningham, J. F. Dixon, Jr., J. D. Maguire, W. W. Power, W. H. Goble, H. N. Ransom, C. N. Leet, J. J. Nef, S. I. Wales, J. S. Hamlin, C. G. Burton, W. L. Waters, W. J. Richards and C. D. Knight.

The Stanley Electric Manufacturing Company, of Pittsfield, Mass., showed a large interurban truck equipped with two S. K. C. 402 motors. One S. K. C. 401 motor was also exhibited showing the careful and thorough construction employed by the Stanley Company, one improvement of great value being the thorough ventilation of the motor. The company also had on exhibition two S. K. C. 2 controllers, trolley stands, switchboards and car circuit-breakers. S. T. Dodd, M. C. Canfield, H. R. Wilson, R. H. Hamlin and George C. Robb represented the company.

General Electric Company had a handsomely decorated booth at the center of the lawn, but made no display of apparatus, reserving its energies for the special excursion which it gave on Thursday, taking a train-load of delegates to its works at Schenectady and there providing lunch, as well as opening all of its departments for inspection, including that devoted to the Curtis steam turbine. At Saratoga the General Electric Company was represented by J. R. Lovejoy, W. J. Clark, J. G. Barry, C. C. Pierce, J. J. Mahony, E. H. Mullin, F. H. Gale, T. B. Bailey, F. T. Barbour, George D. Rosenthal, J. C. Kalisch and W. B. Potter.

The H. W. Johns-Manville Company, of New York, exhibited the most recently developed devices pertaining to the Sachs "Noark" enclosed fuse apparatus. There were several fuse boxes of large capacity, a service box and also some new designs of fuses. A complete line of the latest overhead line material, ears, clips, trolley wheels, insulated and metallic crossings and section insulators was displayed, as well as a complete line of electric car heaters. J. W. Perry, J. E. Meek, H. M. Voorhis and James Humphreys represented the company. The Johns-Pratt Company, which manufactures the overhead line material and "Noark" fuses, of which the Johns-Manville Company is the sole selling agent, was represented by E. B. Hatch and J. Sachs.

The Westinghouse Electric & Manufacturing Company confined its exhibit this year to the two things of most interest to electric railway men, namely, the new turret train control and the single-phase alternating current railway motor. The turret controller, with two motors connected therewith, was shown for the first time; the single-phase railway motor, it was stated, had been in service several months without sandpapering or turning down the commutator and was in first-rate condition. An array of Westinghouse representatives were present; those connected with the company were: L. M. Aspinwall, N. S. Braden, P. T. Brady, J. L. Crouse, E. Dryer, H. P. Davis, D. E. Drake, A. F. Elers, T. C. Frenyear, J. R. Gordon, T. P. Gaylord, E. W. T. Gray, E. M. Herr, Arthur Hartwell, I. R. Ingersoll, W. W. Lovell, D. E. Manson, M. M. Murrill, E. D. Mills, W. M. McFarland, C. F. Nudbury, F. B. H. Paine, W. M. Probasco, Geo. W. Pulver, W. S. Rugg, C. W. Register, S. B. Storer, N. W. Storer and C. Townley.

PERSONAL.

MR. EVERETT T. MALLORY, represented with conspicuous success the Electrical Workers Local No. 103, of Boston, at the International Convention held September 14 at Salt Lake City.

MESSRS. L. W. SEELIGSBERG and F. W. EWALD have severed their connection with The Consolidated Schools, New York.

MR. G. O. DIXON, of Scranton, Pa., has been appointed general manager of the Allis-Chalmers Company's manufacturing plants.

MR. B. OVERLY has been appointed general manager of the United States Telephone Company, Cleveland, Ohio, to succeed Mr. H. H. Robinson, whose resignation is noted in this column.

MR. J. R. LOVEJOY, of the railway department of the General Electric Company, was recently presented by the members of the railway department staff with a handsome silver punch bowl and ladle.

MR. DAVID HALL has resigned his position as chief engineer of the Milwaukee Electric Company to accept a responsible place on the engineering staff of the Bullock Electric Manufacturing Company.

MR. H. H. ROBINSON has resigned the general management of the United States Telephone Company, Cleveland, Ohio, to accept the same position with the Illinois Telephone & Telegraph Company, Chicago.

MR. ALBERT SCHEIBLE, of the George Cutter Company, Chicago, was married on September 19 to Miss Anna M. Leary, of the same city. Mr. Scheible is one of the most active workers in the Chicago Electrical Association.

MR. L. W. KITTMAN, who has made hosts of friends for the Marshall-Sanders Company in the East by his energy and geniality, will hereafter make his headquarters in Chicago and devote his entire time to the Western territory from Pittsburg to Denver.

MR. JOHN H. BARKER, who has been connected with the well-known firm of H. B. Coho & Co. for several years, has left that firm to accept the general sales agency for the Mechanical Appliance Company for all territory east of Pittsburg and Buffalo.

MR. R. J. RUSSELL has severed his connection with the Wagner Electric Manufacturing Company, St. Louis, to accept a position of business and sales manager of H. E. Lindsey & Co., St. Louis, manufacturers of alternating-current ceiling fans. Mr. Russell will enter upon his new duties on October 15.

MR. FRANCIS GRANGER, the efficient Eastern representative of the Sterling Electrical Manufacturing Company, Warren, Ohio, has also been appointed Eastern sales manager for Leo Kaufman, Pittsburg, manufacturer of coloring solutions and frosting for incandescent lamp bulbs. On account of the rapid increase in business, Mr. Granger has taken larger quarters in the Havemeyer Building, 26 Cortlandt Street, New York.

MR. L. F. MAHLER, formerly Chicago district manager for the De Laval Steam Turbine Company, has been appointed St. Louis district manager for the Bullock Electric Manufacturing Company. Mr. Mahler's headquarters are at 1505 Chemical Building, and his territory includes Arkansas, the two Dakotas, Indian Territory, Kansas, Missouri, Nebraska, Oklahoma, the southern half of Illinois and the northern half of Texas.

MR. THOMAS C. WOOD, president of the Ball & Wood Company, the well-known high speed engine builders, has just returned to New York, from Europe. He visited England and the Continent, making casual observation of technical affairs; but the bulk of the time—some two months—was spent with a friend in a delightful walking tour through Switzerland. Mr. Wood finds himself greatly benefitted by this quiet and leisurely experience.

MR. BYRON BRIGGS BRACKETT, A. M., PH. D., has been appointed to the chair of Physics and Electrical Engineering at the Thomas S. Clarkson Memorial School of Technology, Potsdam, N. Y. Dr. Brackett is not only an experienced tutor, but has had considerable experience in practical electrical engineering, having had charge of the inspection and testing of all the cable manufactured by the General Electric Company for the U. S. Army during the Spanish-American war, as well as other important work.

TRADE PUBLICATIONS.

ELECTRIC SIGN FLASHERS. Reynolds Electric Flasher Manufacturing Company, Chicago.—Two attractive cards containing brief statements relating to the advantages of electric flashers.

SMALL MOTORS. General Electric Company.—This is catalogue No. 1044, executed in the handsome style characteristic of General Electric publications and devoted to direct-current and alternating-current motors of 20 horse-power and under.

ELECTROMAGNETS. Varley Duplex Magnet Company, Providence, R. I.—Catalogue No. 10-B, devoted to the Varley process of winding magnet coils and descriptive of the product of the Varley Company.

PORCELAIN SOCKETS. Pass & Seymour, Solvay, N. Y.—A pocket-size pamphlet containing well-executed illustrations of the P. & S. line of sockets, together with the usual tabulated data relating to the line.

ALLFREE EXPANSION ENGINES. The Ironton Engine Company, Ironton, Ohio.—A catalogue of standard size, containing an illustrated description of the Allfree engine which is now built by the Ironton Company. The catalogue is well executed and amply illustrated.

THE NEW AMERICAN TURBINE. The Dayton Globe Iron Works Company, Dayton, Ohio.—Catalogue M., containing illustrations of the New American water turbine, together with the usual data relating to wheel performance under various heads and a great deal of useful hydraulic data.

TELEPHONES. Stromberg-Carlson Telephone Manufacturing Company, Chicago and Rochester.—Circular No. 25, containing illustrations of the principal parts of the Stromberg-Carlson central energy intercommunicating system, together with a partial list of users of this apparatus.

INDUSTRIAL ELECTRICITY. Sargent, Conant & Co., Boston, Mass.—This is a very interesting little pamphlet, containing an explanation of the class of work undertaken by this company, and a discussion of its methods and the results accomplished by them.

DIRECT-CONNECTED RAILWAY GENERATORS. Westinghouse Electric & Manufacturing Company.—Circular No. 1044, containing illustrations, descriptive matter and tabulated data relating to the well-known Westinghouse direct-current railway generators for direct mounting or coupling.

INTERIOR TELEPHONE SYSTEMS. The Holtzer-Cabot Electric Company, Boston, Mass.—Bulletin No. 148, superseding bulletin No. 115 and containing a description of the entire line of Holtzer-Cabot intercommunicating apparatus, profusely illustrated by means of handsome half-tone engravings.

WATER PURIFICATION. American Steel & Wire Company, Chicago and New York.—This is a booklet on the subject of water purification by means of sulphate of iron, and contains some interesting statistics and arguments relative to the system manufactured by the American Steel & Wire Company for such purification.

STOW MULTIPLE-SPEED MOTORS. Stow Manufacturing Company, Binghamton, N. Y.—Although this publication is designated "Bulletin No. 52," it is in fact a very complete catalogue with a cover of heavy substantial paper, and is profusely illustrated with pictures of the well-known Stow motor, its various parts and typical installations.

ELECTRIC GLASSWARE. The Phoenix Glass Company, Pittsburg.—This is catalogue No. 15 and is a superb specimen of the printer's art. It contains handsomely executed illustrations of the complete Phoenix line of gas and electric globes, each plate of illustrations being faced with a table of data and prices applying to the illustrations.

TELEPHONE INSTRUMENTS AND EQUIPMENT. Eureka Electric Company, Chicago.—Catalogue No. 23, containing illustrated descriptions of the well-known Eureka line of telephone wall and desk outfits, transmitters, receivers, generators, switchboards and other appurtenances. The catalogue is handsomely executed and contains some extremely useful diagrams of switchboard and desk set connections.

SMALL DIRECT-CURRENT MOTORS. The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3042, superseding bulletin No. 3028 and containing an illustrated description of the Emerson line of direct-current motors, which ranges from 1/8 horse-power to 2½ horse-power. These are extremely compact little machines and the constructional details as set forth in the bulletin should prove interesting to dealers and users of this class of apparatus.

PERKINS SPECIALTIES. The Perkins Electric Switch Manufacturing Company, Bridgeport, Conn.—This is the latest edition of the Perkins catalogue and is notable for its compactness, logical arrangement of the contents, and the excellent execution of the book itself. The lines include lamp sockets of all modern types, wall receptacles, rosettes, plugs and sockets, snap switches of both the rotary and push-button type, knife switches with and without fuses, Edison plug cut-outs, tablet boards, transformer cut-outs, cluster balls, gas attachments, and wire connectors. The catalogue is protected by a substantial cover of dark green buckram and the corners are rounded to a liberal radius to prevent dog-earing.

BUSINESS NEWS.

J. HOLT GATES, Chicago agent for the Skinner Engine Company, reports a brisk business in his territory. Recent sales include several engines for direct connection to dynamos.

STONE & WEBSTER, Boston, Mass., have removed their headquarters from No. 84 State Street to the new India Building, at the corner of State Street and Merchants' Row. The firm will occupy suites on the ninth, tenth and eleventh floors of the India Building.

THE WILLARD STORAGE BATTERY COMPANY, Cleveland, Ohio, recently closed an order with the Truscott Boat Manufacturing Company for thirty-one sets of Willard batteries to be used for operating launches at the St. Louis Exposition next year.

THE NERNST LAMP COMPANY, Pittsburg, Pa., has established an agency for the sale of the Nernst lamp and supplies with the W. G. Nagel Company, Toledo, Ohio. The New York sales office of the Nernst Lamp Company has been removed from the Equitable Building to No. 11 Pine Street.

THE PLUNGER ELEVATOR COMPANY has removed its New York office from 156 Fifth Avenue to room 509 Whitehall Building, No. 17 Battery Place, in order to obtain increased office space. The company recently closed a contract through the New York office for ten elevators to be installed in the new factory building of the Eaton, Cole & Burnham Company, Bridgeport, Conn.

THE ENGINEERING PUBLISHING COMPANY, Cleveland, Ohio, announces that the well-known periodical *Steam Engineering*, was consolidated with *The Engineer*, beginning with the issue of September 1. Subscribers to *Steam Engineering* will receive *The Engineer*, which is a semi-monthly, in place of the old paper, which was monthly.

C. W. HUNT COMPANY, West New Brighton, N. Y., reports that the Hunt coal-handling equipment installed at the Lincoln Wharf Power Station of the Boston Elevated Railroad recently lowered the world's record for rapid unloading. The coal was raised 90 feet above tidewater and delivered to the storage bins at the rate of 320 tons an hour.

BURT MANUFACTURING COMPANY reports a continued rush of business in Cross oil filters. The company recently shipped 18 filters to Germany, 4 to the Argentine Republic, 16 to London, and a large number of original and repeat orders to American users. The Cleveland Electric Illuminating Company, for example, recently sent in a duplicate order for a 200-gal. filter with an automatic separating device.

MARSHAL-SANDERS COMPANY, Boston, announces that the 1903 model of its push-button switch, which was recently exhibited at the National Electrical Contractors Convention, Detroit, has been adopted by one of the largest electrical contractors in this country and some of the most prominent contractors in various states throughout the country. The new switch is insulated with mica and made to fit all conduit boxes and to require only one style of face plate.

H. T. PAISTE COMPANY, Philadelphia, Pa., announces that the recent purchase of a pottery, together with the expansion of the company's electrical supply business, has made it necessary to transfer to the home office the energetic secretary of the company, Mr. A. E. Jenkins, who has hitherto been in charge of the Western office and warehouse in Chicago. The Chicago office has been put in charge of James Wolff, Western sales manager of the New York Insulated Wire Company, who will handle the Paiste Company's Western business in connection with his wire business.

THE STANDARD ELECTRICAL MANUFACTURING COMPANY, Niles, Ohio, is meeting with much success in the sale of its White Star incandescent lamp, a feature of which is an opal dome-shaped reflector enclosing the upper half of the lamp and attached to a brass ring which is held to the base plug of the lamp by bayonet grooves and pins, no separate holder being employed. The complete outfit is very convenient and very attractive in appearance, the absence of the usual clumsy shade-holding attachment giving the lamp an extremely neat and symmetrical appearance. The lamps, of course, are made in the usual voltages and candle-powers.

THE NEW CENTURY CORRESPONDENCE SCHOOLS, Wilkesbarre, Pa., although organized less than a year ago, has shown extremely rapid growth. The courses of study afforded by the schools are as follows: A complete architectural course; architectural drawing and design; architectural drawing alone; building contracts; chemistry, mechanical engineering; mechanical drawing and designing; electrical engineering; electric power and lighting; telephone engineering; civil service; all branches of English; a teacher's course; college preparatory course; book-keeping and office methods; stenography and typewriting; commercial art and illustrating; lettering, card writing and sign painting; caricature and cartoon.

WESTERN ELECTRICAL SUPPLY COMPANY announces that owing to the constant growth of business during the past ten years it has become advisable to increase its capitalization and divide the business into two departments. That portion of the business relating to electrical supplies has been sold to the Wesco Supply Company, just organized for the purpose with an ample capital, and the business in railway supplies, electrical engineering and construction work will be retained by the old company. Both companies will be officered by old employees of the Western Electrical Supply Company, this company continuing under the effective management of Mr. H. K. Gilman, its president, while the Wesco Supply Company will be under the management of Mr. R. V. Scudder.

SANGAMO ELECTRIC COMPANY, Springfield, Ill., has been obliged by increased business to add to its factory a brick building three stories high and containing 15,000 square feet of space. The new building will be ready for occupancy about the middle of November and when finished and equipped will more than double the present capacity of the factory. This progressive company has just put on the market a duplex form of the well-known Gutmann wattmeter for alternating-current circuits, in the sale of which the Electric Appliance Company, Chicago, reports most gratifying results. The duplex meter receives its name from the fact that it may be connected up for use on either 50-volt circuits or 100 volts, the only change necessary being to shift the shunt wire connection from one binding post to another.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY has removed the New York offices of its sales organization to the new Hanover Bank Building at the corner of Nassau and Pine Streets, the mail address being No. 11 Pine Street. At the Pine Street offices, in addition to the New York sales department, will be located Department I, the export department and the General Agent's offices. The executive, financial and stock transfer offices will remain in the Equitable Building, where the New York headquarters of the Westinghouse Company have been for the past fourteen years. The company reports a continuance of brisk business. Among recent sales of isolated plant equipments may be mentioned an interesting outfit for a cracker and candy factory in Kansas City, in which Westinghouse generators direct-driven by Straight Line engines will constitute the power equipment and will supply current for the lights throughout the factory as well as a large number of Westinghouse motors.

MASSACHUSETTS FAN COMPANY, Waltham, Mass., reports an increased number of orders received from mills throughout the country for its Davidson propeller fan. These fans are designed to run at high speeds, and the builders have recently adopted a new style of bearing which is thought to be a considerable improvement over the bearings formerly furnished on this class of apparatus. The box is lined with a sleeve of high-grade babbitt metal, which can be readily taken out and replaced with a new sleeve should it become excessively worn. The removable linings are carried in stock, so that users of the fans can refit a worn bearing without delay and without going to the trouble of rebabbitting the box. Another feature of the Davidson fan which commends itself to practical users is a ball thrust bearing in the rear journal box; this thrust bearing is sent out on all fans above 18 inches in diameter.

THE ELECTRIC STORAGE BATTERY COMPANY recently closed contracts for the installation of batteries of "Chloride" accumulators for the Indianapolis & Northern Railway at Sulphur Springs, Ind., making seven batteries operated by this company, together with an increase in the battery already installed for the same company at Broad Ripple, Ind.; an increase in the two batteries recently installed for the Los Angeles Railway, Los Angeles, Cal., and an installation for the Northwestern Elevated Railway, Chicago. Four new batteries have been contracted for by the Chicago Edison Company, making thirteen batteries operated by that company; an installation for the Paterson (N. J.) Edison Company, an additional battery for the Los Angeles Edison Company, and an additional battery for the New York Edison Company, which makes 22 batteries operated by this company. Isolated lighting and power plants are being installed for the Murphy Building and for Wm. P. Stevenson, at Detroit, Mich.; Alexander Winton, Cleveland, Ohio; F. T. F. Lovejoy, Pittsburg, Pa.; The House of the Good Shepherd, Roxbury, Mass., and for the Irving Building, Louisville, Ky.

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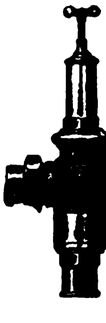

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THE MASON REGULATOR CO., Boston, Mass., U. S. A.

American Electrician.

Vol. XV. New York, November, 1903. No. 11.

MODERNIZED DISTRICT CENTRAL STATION.

POWER PLANT OF THE BRONX GAS AND ELECTRIC COMPANY AT WESTCHESTER, N. Y.

The Bronx Gas & Electric Company has just completed the rebuilding of its central station at Westchester, N. Y., which supplies all of the street and commercial lighting of the annexed district of Greater New York north of the Bronx River, with the exception of the district known as Williamsbridge.

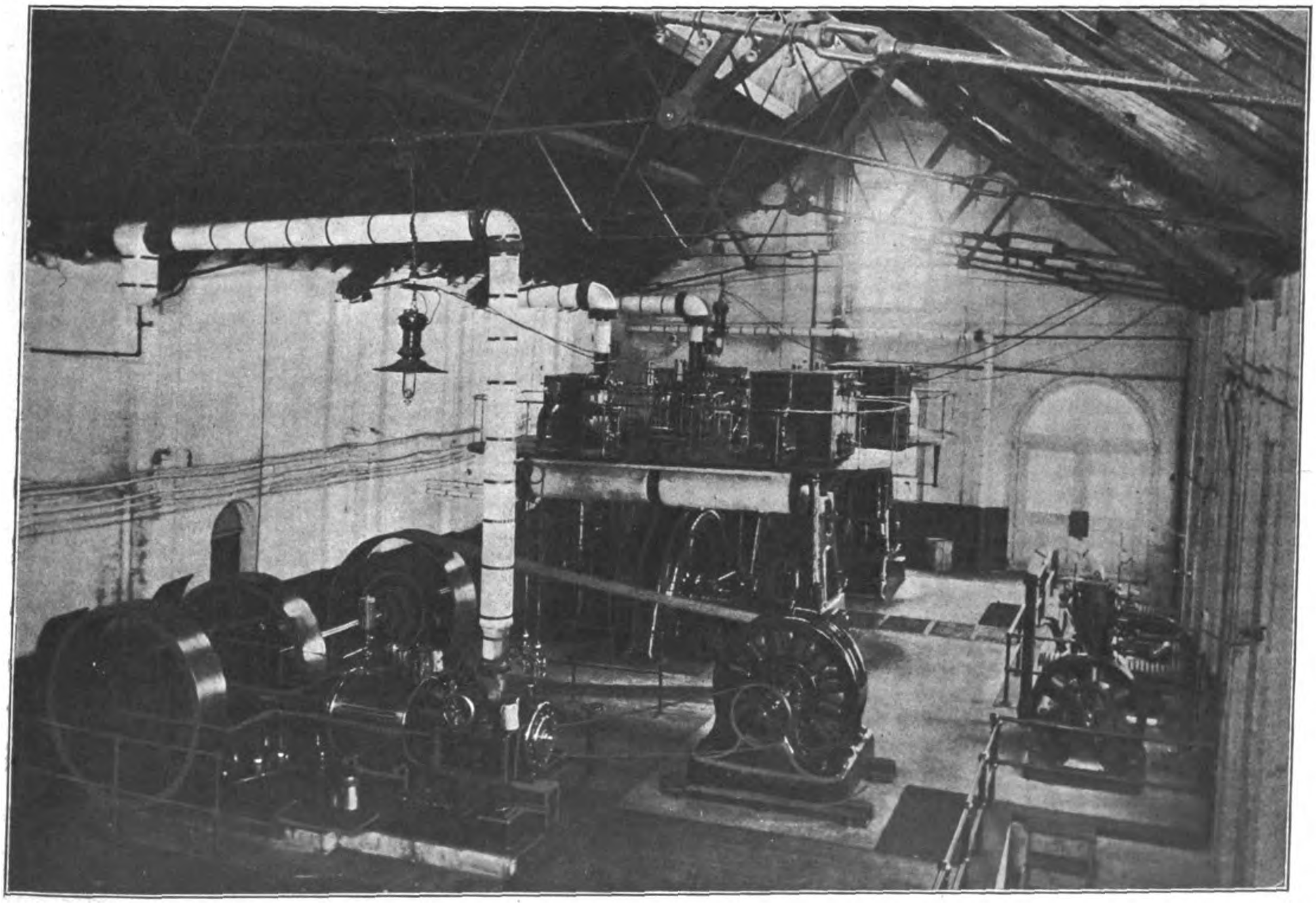

FIG. I.—GENERATING EQUIPMENT OF THE BRONX GAS AND ELECTRIC COMPANY.

Comparison of the reconstructed power-house with the old plant is interesting, owing to the changes in engineering practise which are exhibited. In the new plant two generators take the place of eight 125-light Brush machines and one 75-kw. alternator, which were formerly in use. The two machines require but one-third of the space occupied by the nine old ones, and have nearly doubled their capacity. The new equipment is capable of carrying the present load of the company, but the building is of sufficient size to more than double the capacity if necessary. The location of the machines and piping has been arranged so that new machines can be added as needed without changing the layout of the present equipment.

The power-house is located in a central situation convenient for the lines of the whole system, and stands upon the west bank of Westchester Creek, so that ample supplies of water are obtainable close by for condensing purposes. The greatest distance which current has to be transmitted in any direction at present is about four miles. Fig. 1 shows a general view of the generating equipment in the station, and Fig. 8 is a view showing the other end of the station with the switchboard and transformers.

The boiler room contains at present two Babcock & Wilcox water-tube boilers and two Climax boilers. Each of the Babcock & Wilcox boilers is rated at 365 horse-power, and contains 144 4-in. tubes 18 ft. long, placed 16 wide and 9 high. The boilers are built for a steam working pressure of 160 pounds, and have two 42-in. drums 20 ft. 4 ins. long. The Climax boilers are each rated at 250 horse-power. The boilers are situated on the side of the power-house facing the creek and occupy one side of the building. The arrangements for receiving coal are especially convenient. Coal boats ascend the Westchester Creek to the wharf, where the coal is hoisted and conveyed by an automatic coal handling system built by the John A. Mead Manufacturing Company, of New York City, to a bin having a storage capacity of 2500 tons, situated outside of the power-house, directly in front of the boilers. The boilers are hand fired, the fuel used being anthracite buckwheat coal.

The engine room contains two cross-compound condensing engines of the vertical type built by the Ball & Wood Company, of New York City, running at 150 r.p.m., and rated at 500 horse-power each; and also a 13 x 22 x 16 horizontal tandem-compound Erie Ball engine running at 230 r.p.m., and rated at 225 horse-power. The latter engine is belted through a Hill clutch pulley to a 150-kw. two-phase 2300-volt General Electric generator, having its own exciter belted to it. This unit is used only

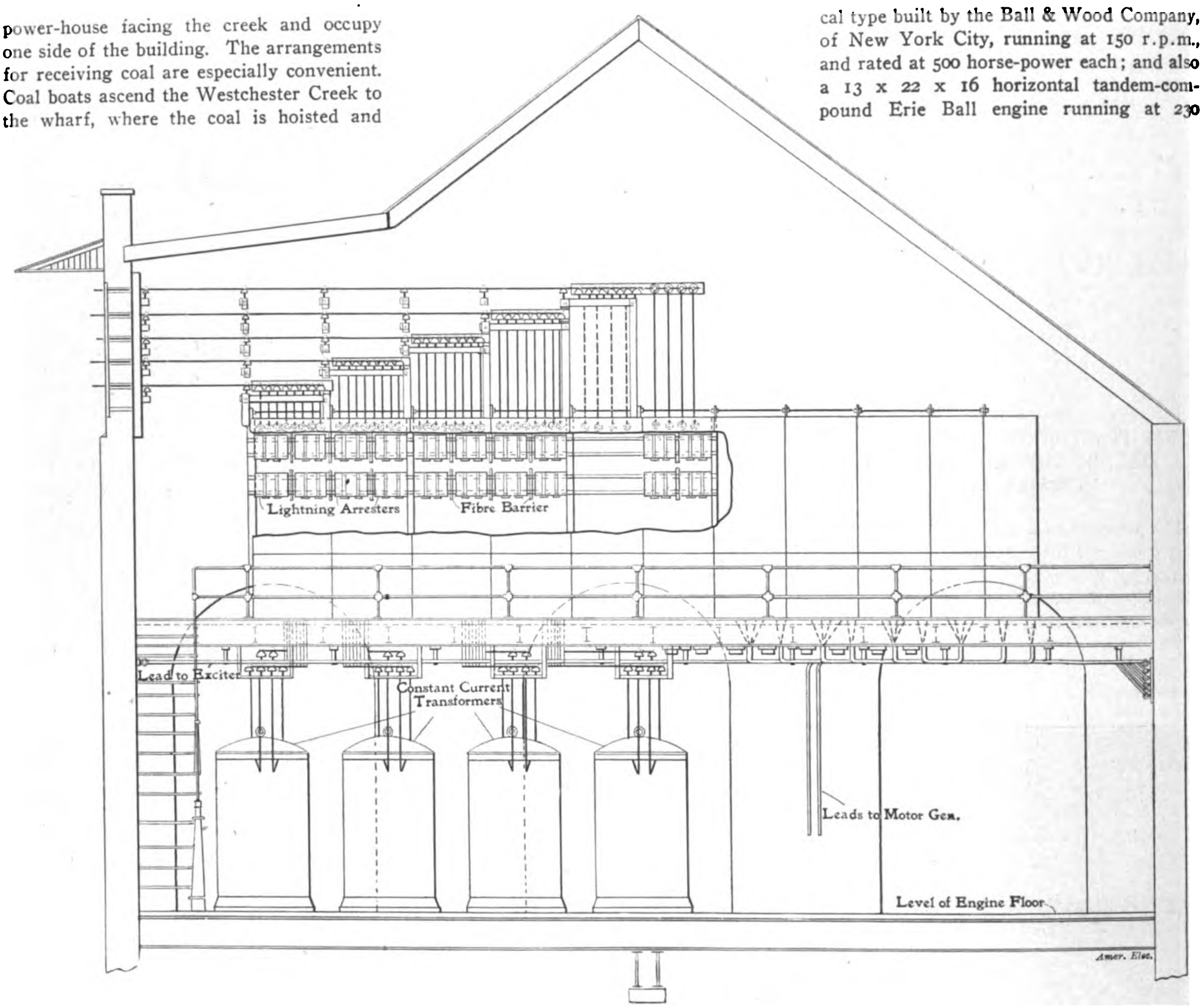
Lightning Arresters
Fibre Barrier
Lead to Exciter
Constant Current Transformers
Leads to Motor Gen.
Level of Engine Floor
Amer. Elec.

FIG. 2.—SECTION OF POWER HOUSE SHOWING ARRANGEMENT OF FEEDERS AND TRANSFORMERS.

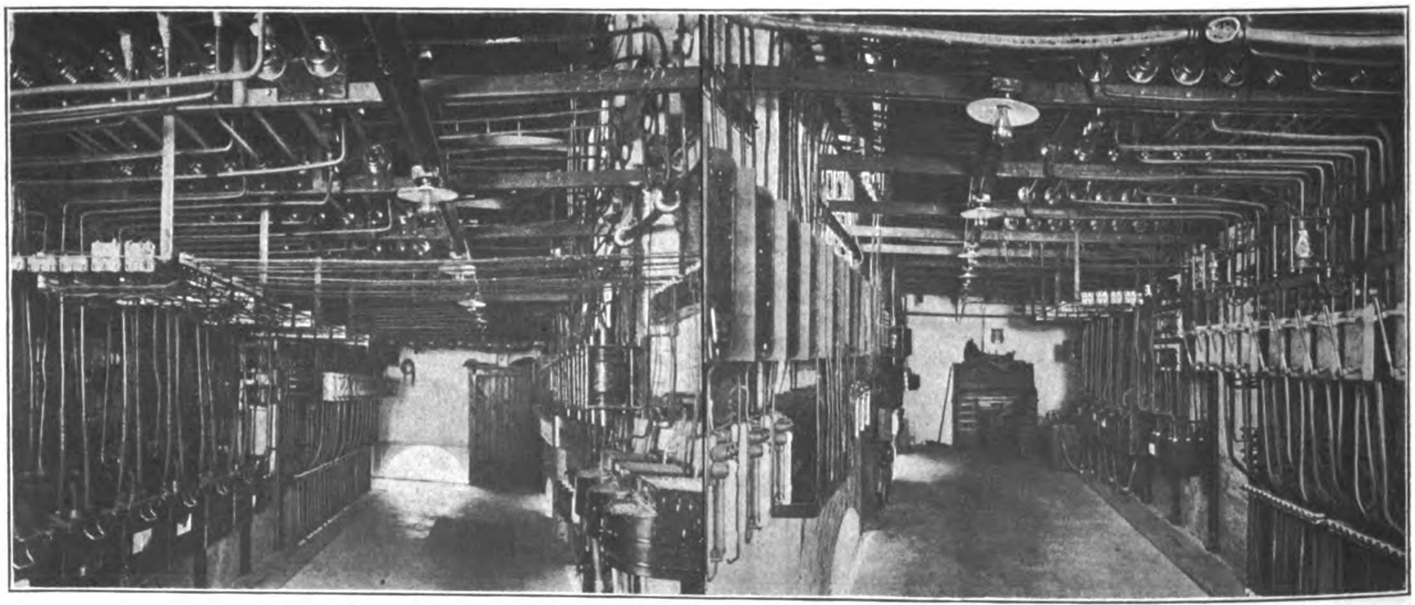

FIG. 3.—TWO VIEWS OF THE REAR OF THE SWITCHBOARD.

during the day, and carries the all-day load of the station. Each of the large engines is direct-connected to a 300-kw. two-phase 2300-volt revolving field alternator of General Electric manufacture. The generators have 48 poles, and deliver current at 60 cycles at a full load efficiency of 93 per cent. They are capable of sustaining a 50 per cent overload for two hours, and a momentary overload of 100 per cent. A duplicate set of exciters is provided for exciting the fields of these generators, the steam-driven exciter set being shown by Fig. 5 and a motor-driven exciter being shown to the right in Fig. 10.

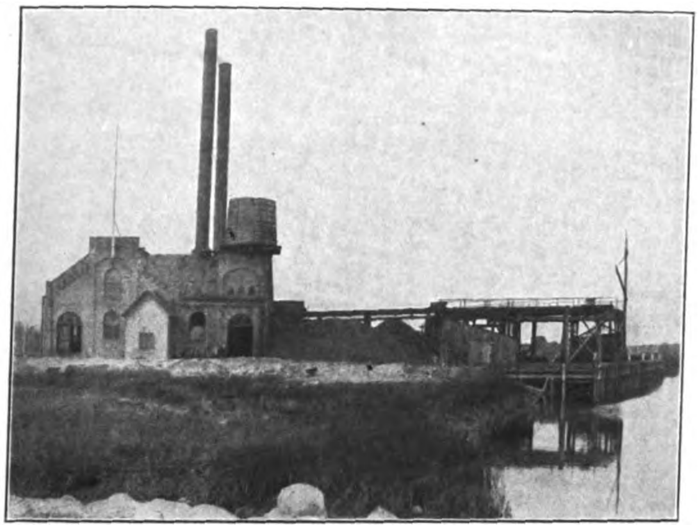
FIG. 4.—VIEW OF STATION SHOWING COALING FACILITIES.

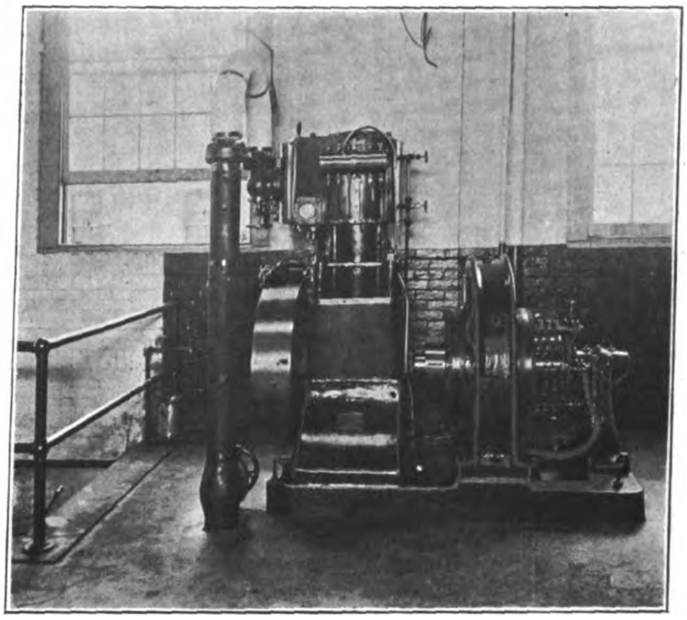
FIG. 5.—STEAM-DRIVEN EXCITER UNIT.

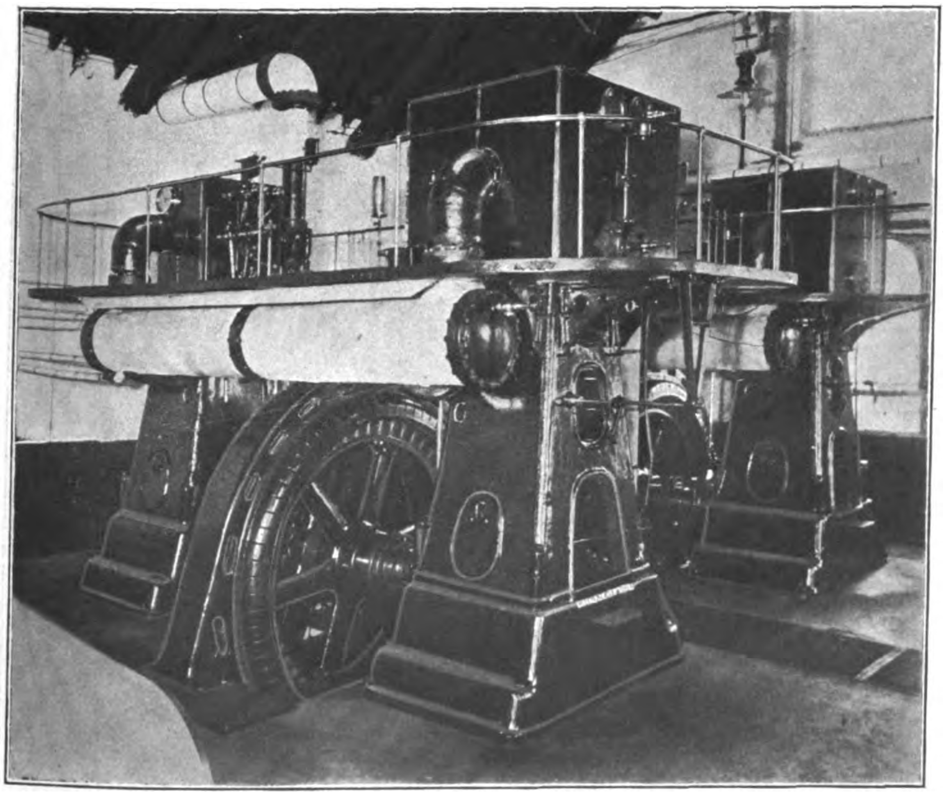
FIG. 6.—VIEW OF MAIN GENERATING UNITS.

There are three Worthington jet condensers placed in two pits on one side of the engine room, each engine having its own condenser. Owing to the nature of the soil, which is very swampy, it was necessary to place these condensers in tanks in order to successfully eliminate the water which would percolate through the soil and also the side walls.

The piping system was installed by Westinghouse, Church, Kerr & Co., of New York City. All of the fittings are extra heavy and the piping is covered with Keasbey's magnesia covering. On each of the boiler outlets is a flanged 7-in. gate valve. Placed on top of this and connecting it with a 10-in. main steam header, is a 7-in. wrought iron bend. The header runs along the wall of the boiler room. Live steam is supplied to each of the engines through a 12-in. auxiliary header acting as a steam reservoir, 7-in. pipe leading from this to the high-pressure cylinder of the engine. A 4-in. steam main is taken from the 10-in. header in the boiler room through a gate valve and runs along the north side of the engine room, turning at right angles and running alongside the condenser pits to the exciter unit. The condenser pumps are fed through 2½-in. pipes connected with the 4-in. main, and a 3-in. connection is led to the exciter engine. The feed-water pumps are fed through a 2-in. line.

From the exhaust outlet of each engine a 10-in. exhaust line runs to the condensers, an atmospheric relief valve being provided so as to exhaust into the atmosphere should occasion require it. A 3-in. exhaust line joining a 5-in. main exhaust pipe carries all of the exhaust steam from the condenser pumps, feed-water pumps and exciter unit through the feed-water heater. The heater is a National heater of 1000 horse-power capacity, and rests upon the floor of the boiler room. The main feed-water supply line is 4 ins. in diameter, and connects with the city water mains, although an artesian well can be called upon if necessary. Duplicate Stilwell-Bierce & Smith-Vaile pumps supply the boilers through the feed-water heater, which is bypassed so that it may be cut out for cleaning or in case of accident.

The condenser injection is connected with the Westchester Creek by a 12-in. line. This runs outside of the building and connects with the inlet of the condenser through an 8-in. cast iron pipe. The discharge from the condenser flows off through a 14-in. pipe to the creek.

The Ball & Wood engines, as stated, are of the vertical compound type, with cylinders 19 and 38 ins. in diameter, and an 18-in. stroke and are built for parallel operation. The frames are of the 500 horse-power class; but the conditions of load at the station made it expedient for the builders to alter the cylinders to a size somewhat smaller

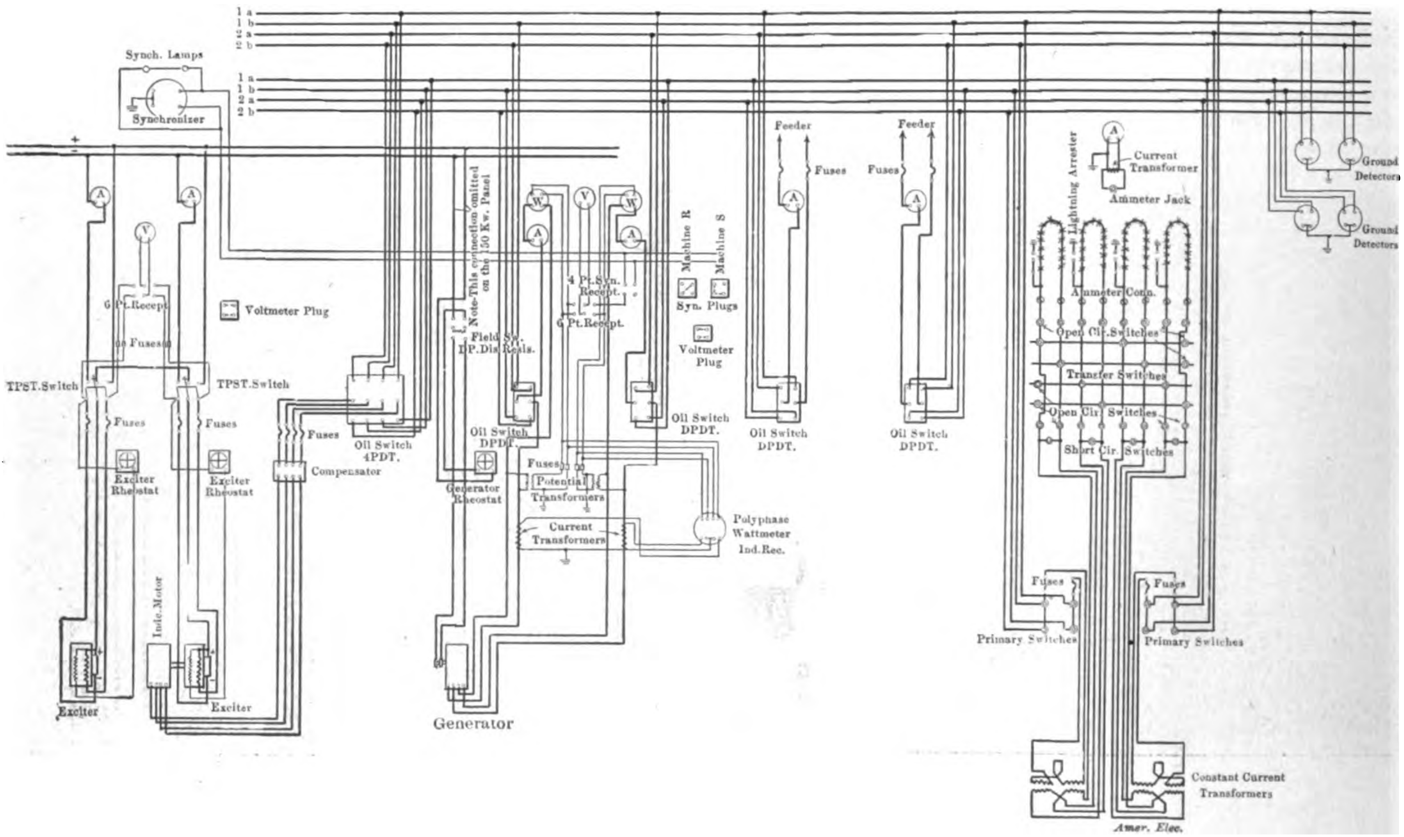
1 a
1 b
2 a
2 b
Synch. Lamps
Synchronizer
A
V
6 Pt. Recept.
Fuses
Voltmeter Plug
TPST. Switch
TPST. Switch
Fuses
Fuses
Exciter Rheostat
Exciter Rheostat
Fuses
Compensator
Oil Switch 4PDT.
Indc. Motor
Exciter
Exciter
Note-This connection omitted on the 150 Kw. Panel
W
Field Sw. DP. Dis. Resis.
4 Pt. Syn. Recept.
6 Pt. Recept.
Oil Switch DPDT.
Generator Rheostat
Fuses
Potential Transformers
Current Transformers
Oil Switch DPDT.
Machine R
Machine S
Syn. Plugs
Voltmeter Plug
Polyphase Wattmeter Ind. Rec.
Generator
Feeder
Feeder
Fuses
Fuses
Oil Switch DPDT.
Oil Switch DPDT.
Lightning Arrester
Current Transformer
Ammeter Jack
Ammeter Conn.
Open Cir. Switches
Transfer Switches
Open Cir. Switches
Short Cir. Switches
Fuses
Fuses
Primary Switches
Primary Switches
Constant Current Transformers
Ground Detectors
Ground Detectors
Amer. Elec.

FIG. 7.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

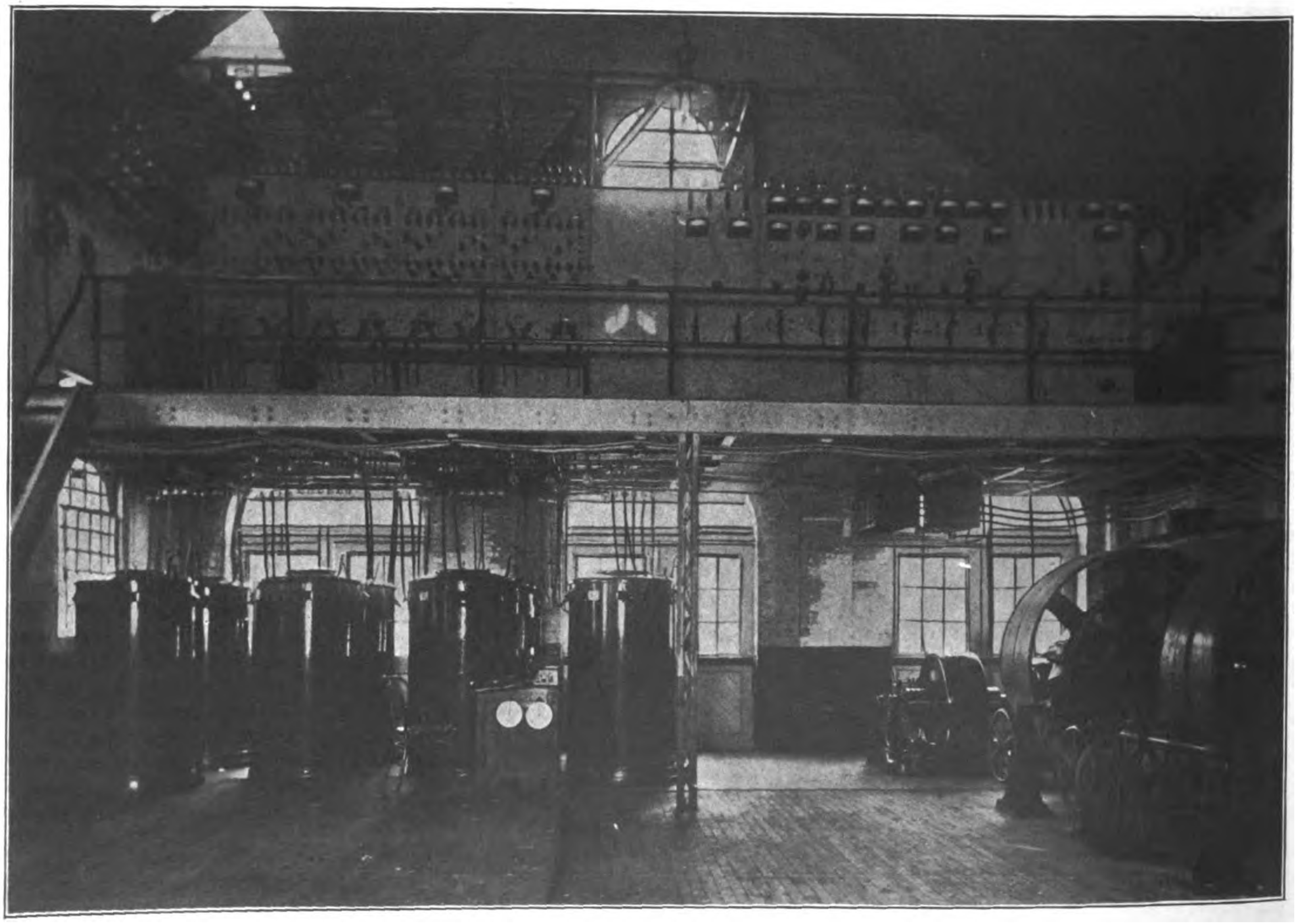

FIG. 8.—SWITCHBOARD END OF THE BRONX GAS AND ELECTRIC COMPANY'S GENERATING STATION.

than that of the regular 500 horse-power type. The engines run at 150 r.p.m. and develop their most economical rating at ¾ load, the steam pressure being 140 lbs. and the cut off ¼ stroke. When operated under full load the steam pressure is raised to 160 lbs., the point of cut off remaining the same. The engines are guaranteed to develop their horse-power rating at an economy of 14 pounds of steam per horse-power-hour with 26 ins. of vacuum and ¼ cut off. A reheating receiver is supported beneath the gallery at the back of the engines. The governor used is of the inertia type with swinging eccentrics. This is provided with two arms and leaf springs, since a powerful governor is required to control the admission valves in the different cylinders. The admission valves are of the Corliss pattern, actuated from a separate wrist plate for each cylinder, which are both controlled by the inertia shaft governor placed in the flywheel of the engine. The exhaust valves are of the Corliss pattern, driven from a separate wrist plate, which in turn is actuated by a fixed eccentric so that each may be adjusted independently of the other, and also of the admission valves, giving a release and compression, which does not vary with the cut off. All the valves are located in the heads of the cylinders, thus reducing the length of the ports and the clearance volume. The admission valves are backed off to permit lifting from their seats for any excessive pressure in the cylinder. Fig. 6 is a nearer view of the two main engines showing a portion of the valve gear. The gear is a simple and compact arrangement having a positive connection between the wrist plate and the valve stem rocker arm; but the layout of the wrist plate and connections is such that a good steam distribution is obtained in the cylinders. The galleries of both the engines are connected so that one may pass from one engine to the other.

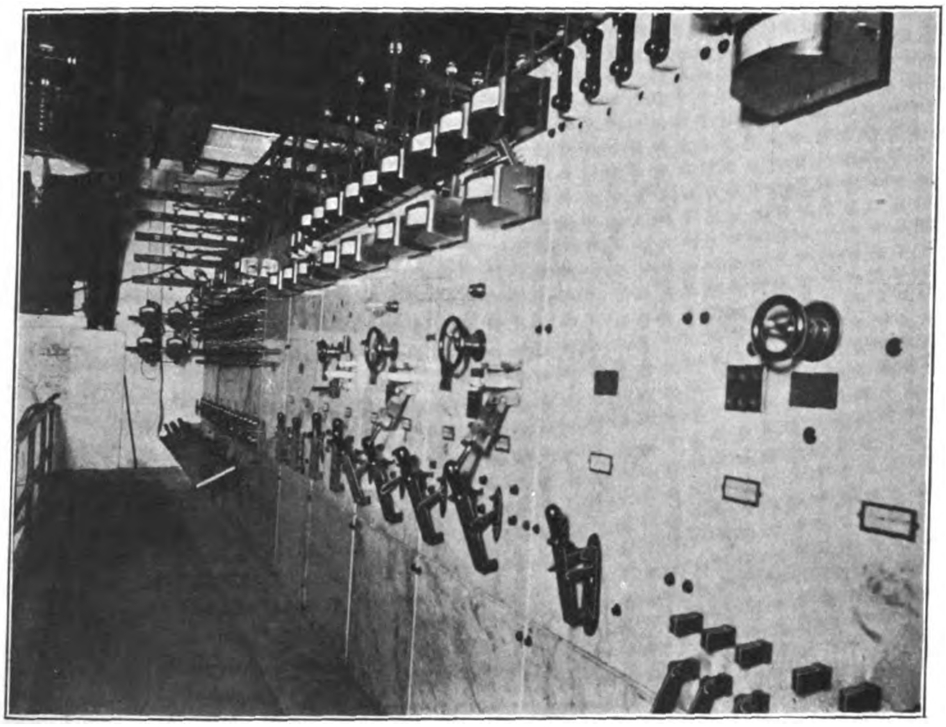

FIG. 9.—VIEW OF SWITCHBOARD.

There are two exciter units, one of which is steam driven and the other motor driven. The steam driven exciter unit is a 30-kw. machine of the General Electric standard marine type running at 305 r.p.m., and delivering 240 amperes at 125 volts. This makes a very compact unit which is used to start up the alternating-current machines when all are shut down. After the machine's fields are built up the steam-driven exciter is shut down and the motor-driven machine used. This later exciter unit is a two-phase induction motor generator of 30-kw. capacity, and consists of a 50-h.p. motor running at 720 r.p.m., and a direct current generator giving 240 amperes at 125 volts. The motor takes 2300 volts, and is connected to both sets of generator busses by a 4-pole double-throw oil switch. Both exciters may be run in multiple if desired. The wires from the steam-driven unit are carried along the inside wall of the building and are lead-covered, while the wires to the induction motor unit drop from the switchboard gallery overhead in heavy rubber-covered cable.

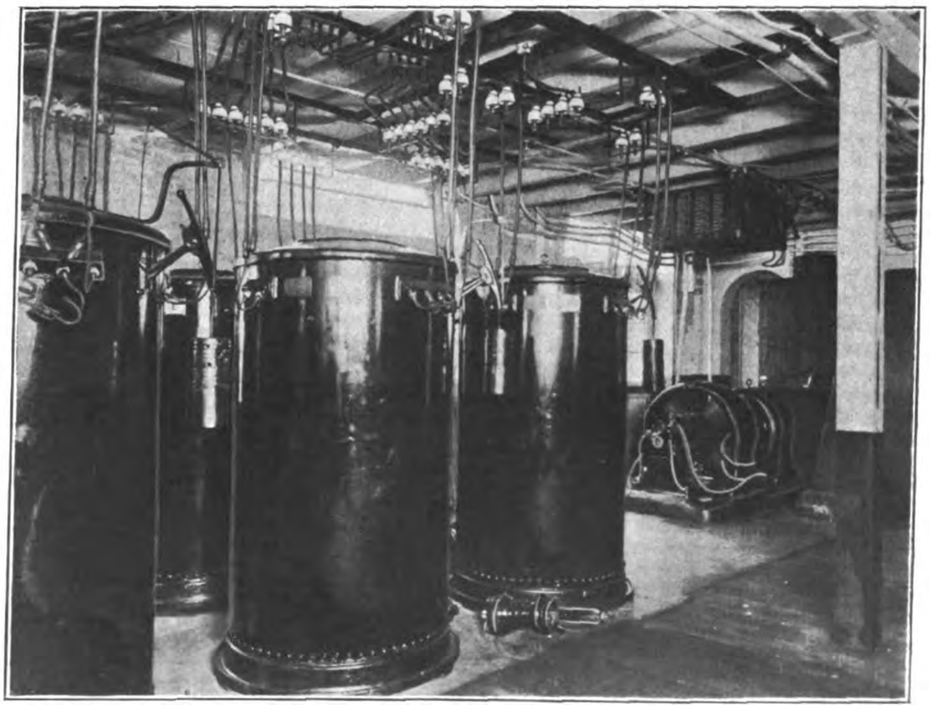

FIG. 10.—TRANSFORMERS AND MOTOR-DRIVEN EXCITER UNIT.

The plant is equipped with a gravity oiling system whereby oil is available under pressure to each oil cup of the engines, thus insuring good lubrication. The system consists of a large storage tank for receiving and storing oil drained from the filter and such additional new oil as is required. From the tank it is pumped by a Worthington oil pump to a gravity tank located high up on the wall of the engine room. From this gravity tank a supply is piped to all of the bearings, etc. The oil as it drains from the various journals of the engines is collected in the crank pits, which are piped to a draining system which discharges into a 60-gallon Cross oil filter situated in one of the condenser pits, where the oil is filtered and pumped again into the oil storage tank and thus used continuously.

The switchboard was built by the General Electric Company. It is provided with two sets of quarter-phase busses and contains 12 panels of blue Vermont marble. These are apportioned as follows: One exciter panel controlling two 30-kw. exciter units; one 2300-volt 50-kw. exciter induction motor generator panel; three 2300-volt 300-kw. quarter-phase generator panels, two of which control the two large generators and the other the 150-kw. unit; one totalizing panel, one feeder panel, and four transformer panels for the arc lighting system; each panel controlling two 100-light constant-current transformers feeding four 50-light circuits. The arc lighting board is arranged so that any circuit can be run on any tub and any tub on either phase of both sets of busses for the purpose of balancing. On one end of the board a Lincoln synchronizer is provided on a swinging bracket, while on the other end, similarly mounted, are four electrostatic ground detectors. Lightning arresters for all circuits are provided on a separate board mounted on the wall back of the switchboard inside the building, and are of

General Electric make. Fig. 9 is a view of the front of the switchboard, and Fig. 3 gives views of the rear of the switchboard. A diagram of the switchboard connections is given by Fig. 7, and the method of running the feeders is clearly shown in Fig. 12. The leads from the generator to the board are all heavy rubber-covered stranded cables encased in lead. The main generator switches provided have their blades and contacts completely immersed in oil, which is contained in a removable iron oil can. When the can is bolted in place against a top casting, which also supports the switch on the panel, the switch is completely enclosed. The switches are operated from the front of the board by a system of levers, and can be thrown more readily and quickly than an ordinary knife switch. Three polyphase Thomson recording wattmeters record all current from each generator; these are mounted on a special rack behind the board. Other details of the board are so clearly shown in the engravings that further comment is unnecessary. The location of the tub transformers directly beneath the switchboard renders the connection to and from the board short and simple, and at he same time permits of their ready inspection.

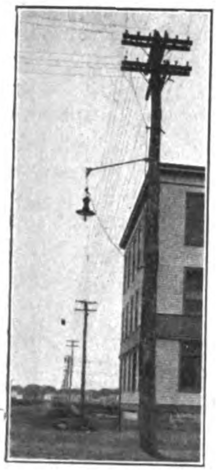

FIG. 11.

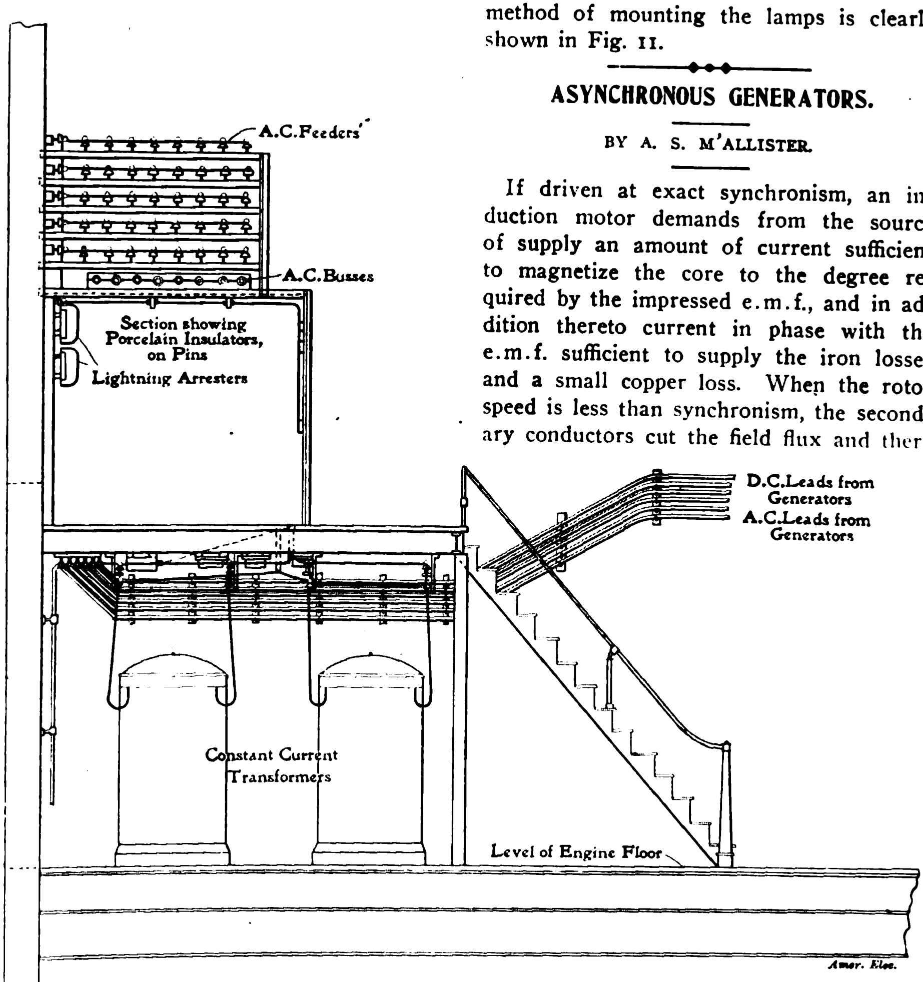
A.C.Feeders
A.C.Busses
Section showing Porcelain Insulators, on Pins
Lightning Arresters
D.C.Leads from Generators
A.C.Leads from Generators
Constant Current Transformers
Level of Engine Floor
Amer. Elec.

FIG. 12.—CROSS-SECTION OF SWITCHBOARD GALLERY SHOWING ARRANGEMENT OF FEEDERS.

The eight oil cooled constant current series transformers used operate on a power factor of 80, and have a full load efficiency of 96 per cent, having connections to the board composed of No. 6 stranded cable with 8/32-in. rubber insulation. The arc lamps used in connection with the system are of the General Electric enclosed type. They operate on the differential principle, with shunt and series magnets, which exert forces on two laminated armatures connected through a lever to a carbon clutch. This insures steadiness in operation, since the shunt and series magnets working in opposition tend to oppose any change in the arc voltage. The lamp is adjusted for the proper voltage at the arc by means of a small sliding weight, which assists the series magnet to strike the arc at the proper voltage and is wound for both 6.6 amperes and 7.5 amperes and thus interchangeable from 1200 candle-power to 2000 candle-power. The carbon tube is slotted, and the carbon holder is connected to the series magnet by means of a flexible cable, which gives a positive connection. A small starting resistance is provided as in all series arc lamps, and a mechanical cut-out is arranged to operate in case of accident. The method of mounting the lamps is clearly shown in Fig. 11.

* * *

ASYNCHRONOUS GENERATORS.

BY A. S. M'ALLISTER.

If driven at exact synchronism, an induction motor demands from the source of supply an amount of current sufficient to magnetize the core to the degree required by the impressed e.m.f., and in addition thereto current in phase with the e.m.f. sufficient to supply the iron losses and a small copper loss. When the rotor speed is less than synchronism, the secondary conductors cut the field flux and there is generated thereby an e.m.f. proportional to the product of the slip and the field strength in maxwells. This e.m.f causes to flow through the impedance of the secondary conductors a current which, being in a magnetic field, gives to the rotor a torque, which if greater than demanded causes the rotor to accelerate, or if less than needed, allows the slip to increase and therewith the secondary current and resultant torque, until a condition of stable running is reached. Since, neglecting the slightly modifying effect of the primary impedance upon the necessary counter e.m.f., the field magnetism must remain at all times of such a value that its rate of change generates in the primary windings an e.m.f. substantially equal to that at the terminals, any current which flows in the secondary is opposed in magnetomotive force by a counter current in the primary. It is this opposing current which appears as the working component of the primary current.

When the slip is negative, that is, when the rotor is driven above synchronism, the e.m.f. generated in the secondary is the same for each value of slip as before, but it is reversed in direction, and the current, which traverses the secondary conductors, is reversed, which necessitates the reversal of the opposing primary current also. Since under the previous conditions of operation the primary working current was a motor current, it now becomes a generator current and tends to transmit energy to the supply system. The torque is also reversed and requires that power be supplied to the rotor from which previously power could have been obtained. The characteristics of such an asynchronous alternating-current generator are similar in many respects to those of the corresponding induction motor; the secondary e.m.f. is proportional to the slip, the secondary current is equal to the secondary e.m.f. divided by the secondary impedance, while the working component of the primary current depends for its value upon the current in the secondary conductors.

An asynchronous generator, as here assumed, will operate satisfactorily in parallel with generators of the synchronous type—the ordinary alternators; the frequency of the current delivered by it, however, is in any case less than that corresponding to the speed of its rotor, the difference being due to the requisite motion of the secondary conductors with reference to the primary field. The division of the load between synchronous generators working in parallel is determined by the relative phase position of the machines; the generator which maintains a phase position in advance of others carrying the greatest load, while one which lags behind in phase position is more lightly loaded. The actual speed of all the generators thus connected, however, must be the same; it is merely the tendency to different speeds, as fixed by the governing mechanism of the prime movers, which determines the load division. As far as concerns the prime movers, the condition of parallel operation of asynchronous generators is quite similar to the above, but in the latter case the load division is determined by the actual operating speed of each individual machine; that is, the load carried by each is determined wholly by the variation of the speed of its rotor from that corresponding to the circuit frequency.

When its speed is below the circuit frequency, an asynchronous generator is driven as an induction motor; which fact allows an asynchronous generator to be connected to the operating circuit without being brought to exact synchronous speed.

As is the case with induction motors, the current which produces the magnetomotive force for field excitation lags 90 degrees behind the e.m.f. of the circuit and must be supplied from some source external to the machine. If this source be a synchronous alternator, the effect of the presence of the exciting current for the asynchronous machine may be eliminated by placing across the generator circuit condensers adjusted in capacity so as to take an amount of leading current equal to the lagging current of the asynchronous generator. (See Fig. 1.) If this adjustment be exact, and there be no fluctuations in the load, no current will pass from the synchronous to the asynchronous machine, and the circuit between them may be opened without producing any effect whatever upon the operation of either machine. Under the conditions here assumed the asynchronous generator will receive its exciting current from the condensers, and, so long as the load remains constant and no changes occur in the speed of the prime mover, it will automatically maintain its e.m.f. at a constant value. If additional load be now placed upon the generator, the e.m.f. will decrease, while, if the load be decreased or removed entirely, the e.m.f. will at once increase; the performance being similar in many respects to that of a direct-current shunt-wound generator.

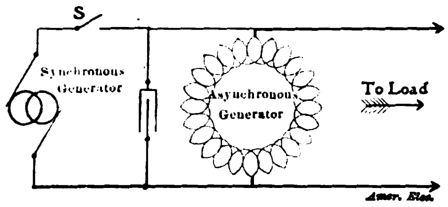

FIG. 1.—ASYNCHRONOUS GENERATOR; CONDENSER EXCITATION.

It is interesting to investigate the effect of varying the condenser capacity in the circuit. Assume that the asynchronous generator is running without load and with condensers adjusted in capacity to give normal e.m.f. If the capacity be increased, more leading current will flow through the condenser circuit, which current will increase the field magnetism of the asynchronous generator and consequently augment the e.m.f. generated; this augmented e.m.f. will further increase the condenser circuit current and thereby the field magnetism and the generated e.m.f., and so on, and, if the reluctance of the path of the magnetic flux remained constant, this increase would continue indefinitely, and the operation of the generator would be impossible. This, however, is not true of any known magnetic material.

The magnetization curve of Fig. 2 shows the relation between the exciting current of an asynchronous generator and the e.m.f. at its terminals. This curve is similar in form to a mean "hysteresis loop" for iron with an air-gap in the magnetic circuit. Each point here, however, represents the relation between the virtual value of the alternating current for excitation and the alternating e.m.f. produced at constant frequency. The several curves of Fig. 2 serve to show quantitatively the effect of a change in the condensance in the circuit. The right line, *O-B*, represents the relation between the current taken by a certain condensance at the chosen frequency and the e.m.f. across the terminals. When the condensance is changed in value, another right line, such as *O-C*, is obtained. Assume a condensance *O-B* in circuit and the asynchronous generator operating at 110 volts. At this voltage the condenser circuit takes 10.3 amperes, which would excite the generator to 129 volts, which would then cause the condenser to take 12 amperes and raise the e.m.f. to 140 volts, and so on, until finally the e.m.f. became steady at 150 volts, which is at the intersection of the condensance line, *O-B*, with the magnetization curve. If now the condensance be increased to the value represented by the line *O-C*, the circuit e.m.f. will rise to 185 volts. It will be appreciated from an inspection of the magnetization curve that any condensance of such a value as to give a line slope less than that of the initial slope of the magnetization curve, such as *O-D*, will be unable to hold the generator e.m.f. at any value whatsoever. When the condensance is of a value sufficient to excite the generator to the point of saturation of its core, that is, of a relative value such as *O-C*, an asynchronous generator will build up its e.m.f. from its weak residual magnetism and need not be connected initially with a source of exciting current.

The foregoing discussion will serve to emphasize the fact that the asynchronous generator refuses to be excited when the condensance is below a certain value and that only above the initial bend of the magnetic saturation curve does the operation become stable. Since the iron loss depends upon the degree of magnetic saturation at which the iron is worked and upon the frequency of reversal of the magnetism, high magnetic density in the primary core would mean excessive iron loss and low efficiency. On account of the slow reversal of the magnetism in the secondary core, however, this portion of the magnetic path may be so designed as to reach a high magnetic density while the primary core is yet much below saturation, under which conditions stable operation and low iron loss may be secured simultaneously.

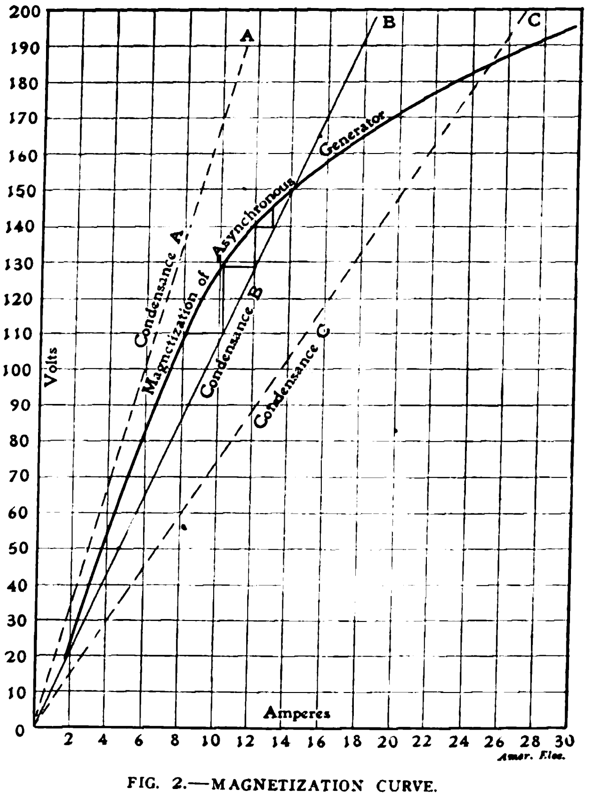

FIG. 2.—MAGNETIZATION CURVE.

When it is remembered that the amount of current taken by a condenser in an alternating-current circuit under a certain e.m.f., varies directly with the frequency, and that the number of magnetic lines of force to produce a given e.m.f. in the generator coils varies inversely with the frequency, it will be appreciated that the e.m.f. which a certain condenser will give to an asynchronous generator will depend largely upon the frequency. The frequency is determined primarily by the speed of the rotor, but it decreases, even for a constant rotor speed, when the generator load increases; a fact which shows the importance of good speed regulation at the prime-mover Any leading current taken by the load acts as additional condenser capacity to increase the generated e.m.f., while lagging current produces the opposite effect; in fact, a condenser-excited generator of this type which operates satisfactorily under a non-inductive load, may be caused to lose its e.m.f. entirely by the addition of a relatively small proportion of inductive load.

Mr. Heyland has devised a method for causing the asynchronous generator to supply its own current for excitation. In the application of his method, current is taken from the main circuit of the generator and passed to the secondary conductors through a suitable commutator on the rotor. The action of the commutator in supplying the exciting current will be appreciated by first considering two extreme conditions of operation. If direct current be introduced by way of slip rings into the secondary windings of an asynchronous generator while the rotor is driven at normal synchronous speed, it will be found that alternating current at normal frequency may be obtained from the primary windings and that the e.m.f. generated may be adjusted in value by a corresponding change in the direct current supplied. In fact, one readily appreciates that operating under the conditions here assumed the asynchronous machine is converted into a simple alternating-current generator and possesses all of the characteristics of this type of machine.

If with the rotor stationary alternating current of normal frequency be supplied to the secondary windings, current at the same frequency may be derived from the primary windings. Under these conditions, the generator is again a source of alternating current, but it now possesses the inherent characteristics of a stationary transformer. If now a commutator be connected to the secondary windings, any motion of the rotor in either direction will not alter the effect of any certain value of current in the secondary in producing e.m.f. in the primary winding, since the space-phase position of the current with reference to the primary coils will be the same as would be the case were the rotor stationary. Hence, independent of the speed of the rotor, the current thus introduced into the secondary reacts upon the primary with the primary frequency. The value of the current in the secondary can be varied by changing the e.m.f. impressed upon the commutator, and it may be given any phase position with reference to its reaction upon the primary by changing the position of the rotor brushes relative to the field coils. (See Fig. 3.)

When the rotor is driven at synchronous speed in the direction of the revolving field, the e.m.f. required to be impressed upon the secondary windings in order to cause a given current to flow therethrough is greatly reduced below the value necessary when the rotor is stationary, due to the practical elimination of the reactive e.m.f. at the low frequency of the current in the individual slots containing the secondary conductors.*

The operation of an asynchronous generator with commutator excitation is quite similar to that of one excited by means of condensers, and the statements made above as to the effect of speed variations and of the character of the load current upon the delivered e.m.f., and as to the necessity of working the magnetic core at high density apply equally to the Heyland shunt-excited asynchronous generator. With a commutator generator, however, it is possible to use compound excitation, which consists in passing the load current, by means of an auxiliary set of brushes on the commutator, through the secondary conductors, and thus to increase the field strength with the load and to counteract the effect of any lagging current upon the field magnetism and the circuit e.m.f. This latter action is very similar to that produced in direct-current generators equipped with the Ryan balancing coils. Since a load current which lags in the primary coils will lag equally in the auxiliary exciting circuit of the secondary, it is possible by means of the compound excitation to compensate for the field demagnetizing effect of an inductive load upon the generator.

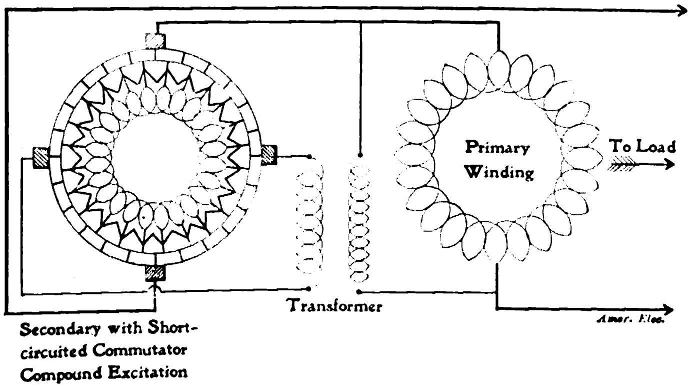
Primary Winding
To Load
Transformer
Secondary with Short-circuited Commutator Compound Excitation
Amer. Elec.

FIG. 3.—ASYNCHRONOUS GENERATOR; COMMUTATOR EXCITATION.

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FLYWHEELS AND FLYWHEEL ACCIDENTS.

R. T. STROHM.

Human ingenuity and reason have done much toward minimizing the dangers of modern life, yet the greatest care and forethought have failed to prevent disasters where great energy is stored for utilization. Steam boiler explosions are responsible for a large number of deaths and the destruction of much valuable property. But if the steam boiler be conceded the unenviable position of first in the line of destructors, the fly-wheel should rank very close to it.

The steam engine flywheel is a reservoir of energy, and the amount of energy contained in it depends upon two factors; the first is the weight and the second is the velocity. In the design of the fly-wheel, also, it is customary to consider the weight as concentrated in the rim, since by far the greater part of the weight of a fly-wheel is contained in its rim. The energy stored in a rotating fly-wheel is expressed by the formula $\frac{wv^2}{2g}$, in which w is the weight of the rim in pounds, v is the velocity of a point at the end of the mean radius in feet per second, and g is the acceleration due to gravity. Manifestly, the value of v varies directly as the mean radius of the rim. Hence, to obtain a given amount of stored energy at a certain rotative speed, it is necessary to adopt one of two methods; either to rotate a very heavy body at a short distance from the shaft axis, or to use a lighter weight and to place it at a correspondingly greater distance from the shaft axis. In practice the latter alternative is adopted, since the former would not only occupy an undue amount of space but would also add appreciably to the friction losses in the engine bearings as well as increase the net weight of the engine.

An inspection of the formula $\frac{wv^2}{2g} = e$ will show that if the mean radius be made very large, the value of v will be correspondingly great, and the weight w may be made quite small, for a given storage of energy, e. However, another consideration enters which prevents the use of a very large radius and necessitates a compromise between a great weight of rim and a great diameter of rim. This influencing factor is centrifugal force, and it is expressed by the formula, $\frac{wv^2}{gr} = f$; r being the radius at which the mass turns or revolves about the axis. It is interesting to note in what manner and to what extent the centrifugal force may be varied. If the weight of the body be doubled, the centrifugal force will be doubled, other things remaining equal; this is quite evident from inspection of the formula. If the velocity be doubled, however, the centrifugal force will be four times as great, since it varies as the square of the velocity. If the radius be doubled, the centrifugal force will be just half as great, assuming no change in the weight or the velocity; conversely, if the radius be made half as great the centrifugal force will be doubled.

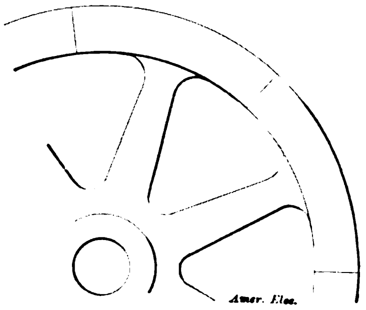

FIG. 1.

If we were to consider the fly-wheel rim as being composed of a number of segments, each independent of the others, and each held to the hub by a single arm, as in Fig. 1, then it would be necessary to proportion the arms for direct tension, due to the outward pull of each segment under the action of centrifugal force. And this is one of the stresses to which the arm of a fly-wheel is subjected. But the arm itself has weight and consequently there is a certain amount of centrifugal force due to the rotation of the arm which further adds to the tension in the arm. As the rim rotates, however, the centrifugal action affects every particle of the material, tending to make it travel in a circle of greater diameter; that is, at a greater distance from the shaft axis. If the rim were a solid ring, then, without spokes or hub, and if it were rotated about its geometric axis, the tendency of each particle to travel in a larger circle would produce a tendency to increase the mean diameter of the rim. This could be brought about only by a lengthening of the rim circumference, from which it is evident that there is a certain tension in the fly-wheel rim due to the tendency of each particle to move radially away from the centre of rotation under the action of centrifugal force.

The tension in the rim section in pounds per square inch is expressed by the formula $T = 0.1\, v^2$, supposing the rim to be of cast-iron, which is the usual fly-wheel material. This formula is obtained in the following manner: Let Fig. 2 represent half the rim of a rotating fly-wheel, AB being a diameter. Suppose a, a, a, etc., to represent the centrifugal forces in the several equal portions of the rim. Resolve these into their components acting at right angles to the diameter *AB*, as *b*, *c*, *d*, etc., Then the sum of all these forces, *b*, *c*, *d*, etc., between *A* and *B* will give the total force tending to tear one half of the wheel from the other half, which would be accomplished by the breaking of the rim at *A* and *B*. This is equal to 0.00010854 WRr^2, in which W is the weight of the rim in pounds, R is the mean radius in feet, and r is the number of revolutions per minute. However, the rim must break in two places, at *A* and *B*, so that the stress on each section is 0.00005427 WRr^2, and this means a stress of 0.0010656 R^2r^2 per square inch of rim cross-section, since the weight W of a rim one inch square is 19.635 R pounds. Since $R^2 = \frac{1}{4} D^2$, we have $0.0010656 R^2r^2 = 0.0002664 D^2r^2 = 0.000027 V^2$, where V is the velocity of the rim in feet per minute. If v represents the velocity in feet per second, then 0.0972 v^2, or practically 0.1 v^2, will be the tension per square inch of rim section at either *A* or *B*.

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* See article by the writer in the AMERICAN ELECTRICIAN, July, 1903.

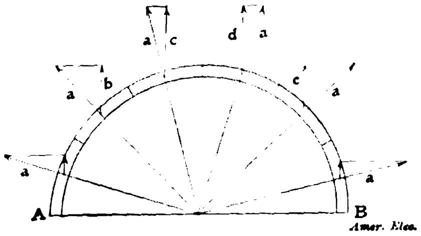

FIG. 2.

From this it will be seen that the strength of the rim depends upon its linear velocity, and by the use of this formula one can readily calculate the safe speed of a cast-iron wheel. At first glance it would appear that if the cross-section of the rim were increased the stress per square inch would be less, and consequently the wheel could be run at a higher speed. However, it must be remembered that as the rim section is enlarged the weight W is increased, and the centrifugal force increases directly in proportion to the weight. Hence it is not feasible to make a wheel stronger by using a greater weight of rim.

A fly-wheel mass does not consist of a simple annular ring revolved about its geometric axis. It consists of a rim, either solid or segmental, to which are attached a number of arms. These arms tend to prevent any enlargement of the rim radius when the wheel is revolved, and therefore they are put in tension. But at the same time they relieve a portion of the rim tension. In other words, the stresses produced by the action of centrifugal force are resisted by the arms and the rim, in each of which a certain tension exists. The exact amount of this tension would be exceedingly difficult to calculate with any degree of exactness; but it has been found by approximate calculations to be about the same in the arm as in the rim. But this is on the assumption that the parts are so adjusted as to pull together properly. In reality, this may not be the case, since there are shrinkage strains due to unequal cooling of the casting, which may give the arms a great initial stress and cause them to carry more than half the stress due to centrifugal force.

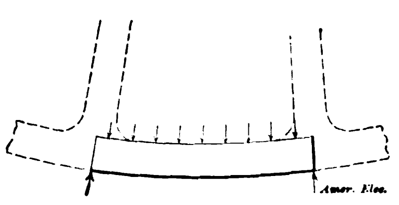

FIG. 3.

While there can be no doubt, therefore, that the rim and arms cooperate in resisting the tensile stresses, yet the uncertainty regarding the relative portion borne by each has led builders to calculate the rim section as though it had to withstand all of the stress set up by centrifugal force. This is due, also, to the fact that the rim is likewise subject to flexure, which would further increase the fiber stress in the material.

The portion of the rim lying between two adjacent arms may be considered as a beam supported at the ends and uniformly loaded. The uniform load consists of the centrifugal force of each particle or section of particles, which acts radially outward. The condition thus set up is like that shown in Fig. 3. In the case of a uniformly loaded beam, the greatest bending moment occurs in the section midway between the supports. Hence the rim is weakest at the points midway between the arms.

Thus far we have considered simply those stresses which are set up when the fly-wheel revolves at a constant velocity. This is not the case in actual practice. The fly-wheel is constantly subjected to alternate increases and decreases of speed, due to the fact that the steam pressure upon the piston, as well as the effective length of the crank, vary throughout the stroke. As a consequence, the turning effort is variable and this sets up a certain periodic fluctuation of speed in the movement of the fly-wheel. The greatest turning effort occurs very nearly at midstroke, in ordinary reciprocating engines, when the crank and connecting rod are at right angles. At this time the fly-wheel is receiving energy, and is being accelerated by the maximum turning effort, transmitted to the rim through the shaft, hub, keys and arms. For a very short time, then, the shaft revolves more rapidly than the rim, and consequently the arms are subjected to bending at the point where they join the hub.

In a large number of cases the fly-wheel is used likewise as a belt wheel. In these instances there is always a certain bending moment exerted on the arms due to the pull of the belt acting at the rim circumference. If each segment be considered as being independent of the others, as indicated in Fig. 4, the belt pull would tend to bend each segment forward in the direction of the pull, and this would cause the segments, at the point of meeting, to slip past each other as indicated. In the actual wheel, however, the rim segments are not free, but are linked or bolted together. Hence, if these ends be pressed into line by the forces *F*, *F*, strains would be set up in the rim similar to those which would exist in actual operation. The strains thus set up are tension in the arm or rim at *A*, and compression at *B*. Since cast-iron is so much weaker in tension than in compression it is customary to consider only the tensile stresses.

From what has been thus far said, it is evident that there is tension in the outer fibres of the rim at *A*, Fig. 5, and also at *B*, in the inner fibres, due to the bending of the rim between the arms by centrifugal force. It must be evident, therefore, that at some point between *A* and *B*, there is a normal condition. That is, a point where there is neither tension nor compression in the rim due to the bending outward of the segment. This point lies practically half way between the end of the arm and the centre, *A*, of the rim segment, and is the point of least stress in the rim.

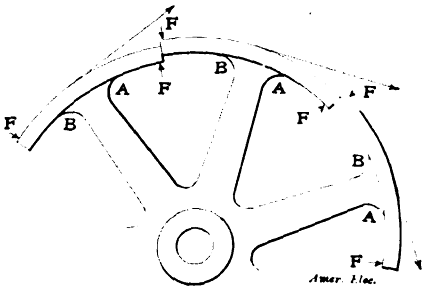

FIG. 4.

The stresses in a fly-wheel may then be summed up in this manner: Tension in the rim, bending in the rim, bending in the arms at the hub and at the rim, tension in the arms due to shrinkage and centrifugal force, and shearing at the middle of the rim segments.

The primary cause of fly-wheel destruction is excessively high rotative speed. This is an era of high-speed engineering, and it needs but a slight amount of investigation to show that the failure of fly-wheels is far more frequent than formerly. Of course, the number of engines has multiplied enormously, but considering this, the percentage of accidents is still larger than before the advent of higher rotative speeds.

A dangerous increase of speed may be brought about through a multiplicity of causes. In numerous instances it has been due to the breaking of the governor belt, allowing the engine to race to destruction. In another instance, the main belt broke, knocked down a pillar supporting the ceiling of the engine room, and the pillar in falling bent the reach rods from the governor in such a manner that steam could not be shut off from the cylinder, thus permitting the engine to race dangerously.

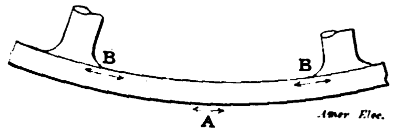

FIG. 5.

In accidents of this nature the initial fracture usually occurs in the rim, since the fibre stress is greatest in the rim. Further than this, the rim is often weakened by joints used in its construction, which would make it the most liable of all parts to failure. By far the safest type of fly-wheel is that cast in one piece. That is, the fly-wheel in which the arms, rim and hub are cast together, forming a single piece of metal without joints. Seldom, indeed, does a wheel of this type burst, and when it does, the cause is usually attributable to flaws in the metal rather than because the wheel was not designed to withstand the effects of high speed.

Ordinary cast-iron has a tensile strength of about 18,000 pounds per square inch. The bursting speed of a solid rim cast wheel, therefore, is equal to $\sqrt{\frac{18,000}{0.1}}$, or about 425 feet per second, a speed considerably higher than that at which cast-iron wheels are usually run. It is customary to make the peripheral velocity of a cast-iron wheel not more than 100 feet per second; at this speed the tension per square inch of rim section is 1000 pounds, which gives a factor of safety of 18; surely a sufficiently large one.

But it is not possible to construct all fly-wheels of the one-piece type, as much because of the difficulties which would be encountered in the foundry as because of the difficulties which would arise in transportation. Hence it is generally found that fly-wheels from 10 to 15 feet in diameter are cast in halves, and bolted together strongly at the hub and at the rim. The joint thus formed at the rim, however, constitutes a weak point in the construction. In the two-piece wheel the rim joint is commonly made by internal flanges on the adjacent parts, through which strong bolts pass. The disadvantage of this method lies in the fact that a large mass of metal is concentrated at the rim joint causing a considerable increase in the bending moment. And since the joint is usually placed at the middle of the rim segment, this additional bending stress falls at the point of greatest bending moment. Consequently, such a type of joint so weakens the rim that it possesses but one-fourth the strength of the solid rim of the same cross-section. In other words, it will fail at half the speed which would be necessary to burst a solid wheel.

Hence, if the fly-wheel has a flanged and bolted rim, its factor of safety at 100 feet per second is but 4½. Now, suppose that this wheel, through racing of the engine, should reach a speed of 200 feet per second, or twice its normal velocity. Since the tension in the rim varies as the square of the velocity, the tension is now four times as great, which practically wipes out the remaining factor of safety, leaving the wheel strained to the point of bursting.

It has already been shown that there is a point in the rim, which may be designated as the point of change of flexure, at which the bending moment is nil. It would seem, therefore, that the location of the flange at this point should result in less strain in the rim. While the idea is reasonable, yet actual tests fail to show any appreciable gain in strength by locating the joints at these points. The explanation of this may lie in the fact that even by such procedure the bending action due to the metal in the bolts and flanges is not far removed from the point of maximum flexure.

The cast fly-wheel is subject to shrinkage strains also, to a greater or less extent, according to the size of the wheel and the shape of its parts. Cast-iron contracts about one-eighth of an inch per foot in cooling, and in so doing often sets up great strains in the arms. There are cases on record in which an arm of a cast-iron pulley has been broken accidentally and the pieces of the arm have pulled apart to a considerable distance, showing that previous to the rupture the arm had been under severe tension, which condition could have been brought about only by the contraction during cooling. The case of the fly-wheel is so nearly like that of the pulley that we may reasonably suppose that similar shrinkage strains are set up in the former.

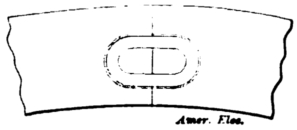

FIG. 6.

Where a mass of metal is concentrated at an angle in a casting, a fault may easily result. In most fly-wheels, a large fillet or curve is used at the juncture of the arm and the hub, with the result that at this point there is concentrated a considerable mass of metal. The same is true at the juncture of the arm and the rim. Now, the outside of this mass, in contact with the sand of the mold, will cool the more rapidly, while the interior may remain molten, or at least plastic, for some time. After the outer shell has once hardened, the shrinkage is away from the centre, leaving a spongy interior, or maybe an actual cavity in the casting. A comparatively recent accident caused by the running away of an engine gave an illustration of this fact. A portion of the rim, with a piece of an arm sticking to it, was found. It had fractured directly through the angle of the junction of the arm and the rim, and the fracture showed at the centre of the break the spongy structure just mentioned.

Fly-wheels of larger diameter are held together in various ways. On belt wheels a flange is usually cast on the inner side of the rim segment, which faces a similar flange on the next adjoining segment, the two being joined by bolts. The objection to this mode of fastening has already been noted. Another device, commonly employed on heavy fly-wheels, is the link and lugs, as shown in Fig. 6. Such a joint has the strength of two-thirds that of the solid rim, and is about as strong a rim joint as can be devised. The link is of steel, and as it is shrunk on the lugs it holds the ends of the segments together firmly. Still another method of making a joint is to use a dowel and cotters, as illustrated in Fig. 7. This type of fastening does not possess quite the strength of that shown in Fig. 6, although it is extensively used on wheels of large size. It can be so adjusted, however, as to bring the initial stress up to any desired amount, which cannot be done with the link and lugs, since the initial stress thus produced is due entirely to shrinkage of the link during cooling, which is not accurately calculable.

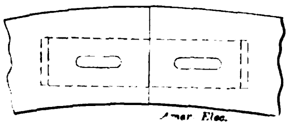

FIG. 7.

Although most cases of disruption of fly-wheels are due to extraordinary speed, the presence of water in the cylinder may wreck a fly-wheel. If a "slug" of water should come over from the boiler to the engine cylinder and be caught in the clearance space at compression, the reciprocating parts, as well as the crank and shaft, would be brought to a sudden standstill, provided the cylinder head and piston remained intact. Such action would throw an enormous stress upon the arms of the wheel, since the hub would stop, if the keys held, while the inertia of the rim would carry the latter forward; this flexure would likely break the arms off near the hub and also near the rim. As commonly designed, a good fly-wheel should be capable of being brought to rest from its normal speed in one revolution without suffering damage. But where the shaft is brought to a sudden stop, as in the case mentioned, disruption would likely follow.

However, an accident of this character would doubtless entail less disaster than one due to abnormal speed, because there would not be the same tendency to scatter the wreckage. One case is recorded in which an accident to a generator armature caused it to be wedged immovably in the pole-faces, throwing a sudden tremendous bending stress upon the fly-wheel, so that it broke. But the greater part of the wheel went into the wheel pit, only a few pieces being thrown to any distance.

The prevention of fly-wheel disasters due to excessive speed has opened a new field to inventive genius, and several devices are on the market which aim to prevent racing of the engines to which they may be attached. The value of an automatic stop of this kind cannot be overestimated, for it will save many times its cost by the prevention of a single accident. But if a fly-wheel is faulty and weak, through incorrect design or poor workmanship or material, it may give way under some sudden increase of stress in spite of any automatic stop that can be devised.

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New Method for Preserving Wood. — A newly discovered process for the preservation of wood consists in forcing zinc sulphate in the wood at one end, driving the sap before it and out at the other end. One end is then sealed and the zinc sulphate solution forced throughout the whole mass towards the surface. Calcium chloride under pressure is then used to penetrate far into the wood. This reacts on the zinc sulphate forming the preservative zinc chloride, which is enveloped and penned in by the almost insoluble calcium sulphate. The double reaction, consisting of the formation of an insoluble guard to prevent loss of the preservative salt, constitutes the chief feature of the process. This is a distinct advance over the old method of steaming the wood to remove the sap.

An Interesting Turbine Installation.

The factory plant of the B. F. Goodrich Company, Akron, Ohio, offers an excellent example of the advantages of power conversion and distribution by the steam turbine and the electric motor, which form the two vitally important factors in the use of power in this plant. The turbine machinery was installed under pressure of necessity due to factory extensions, and its selection resulted from investigation by the management into turbine performance in both domestic and foreign territory.

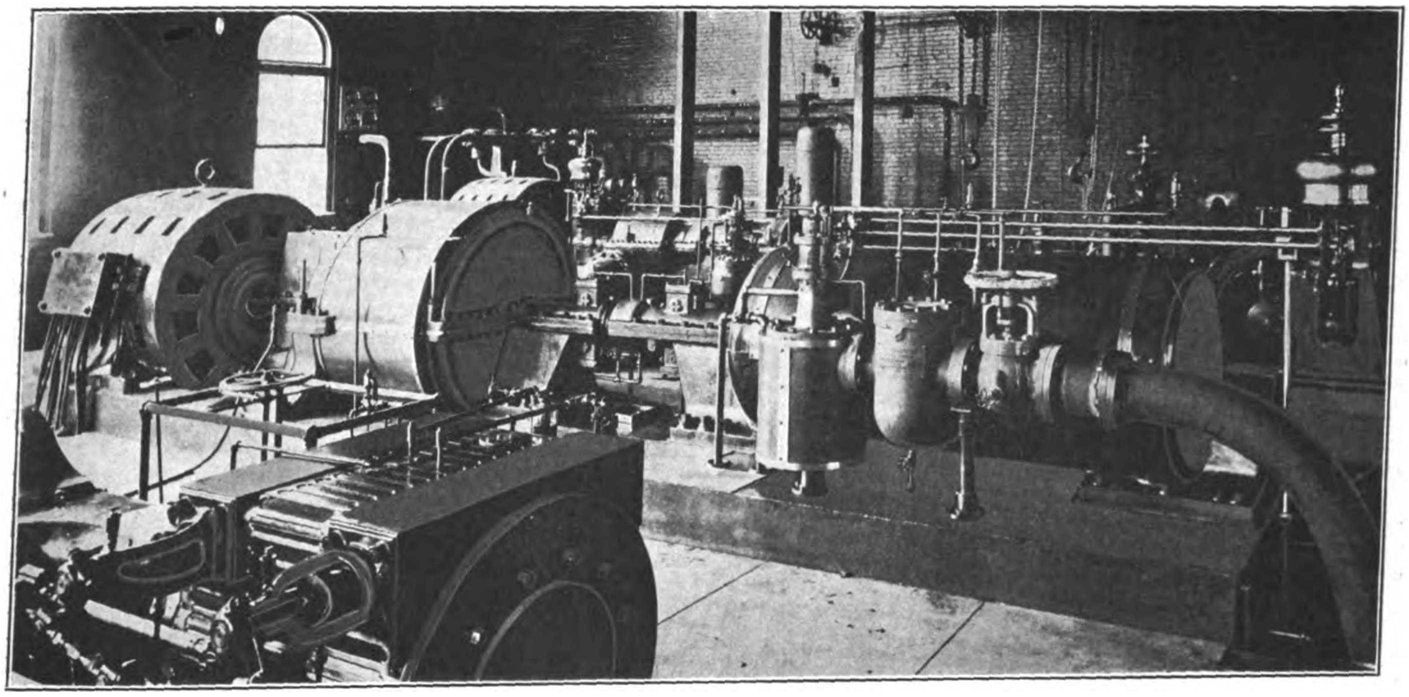


FIG. 1.—VIEW OF TURBO-GENERATOR EQUIPMENT FROM TURBINE END.

The industrial plant of the Goodrich Company consists of an aggregation of buildings devoted to the manufacture of rubber goods, the various processes encountered necessitating many different forms of power applications. A large amount of power is required in operating crude rubber and calender rolls, and large generating capacity is necessary at the power station by reason of the suddenness and severity of loads thrown upon the power system.

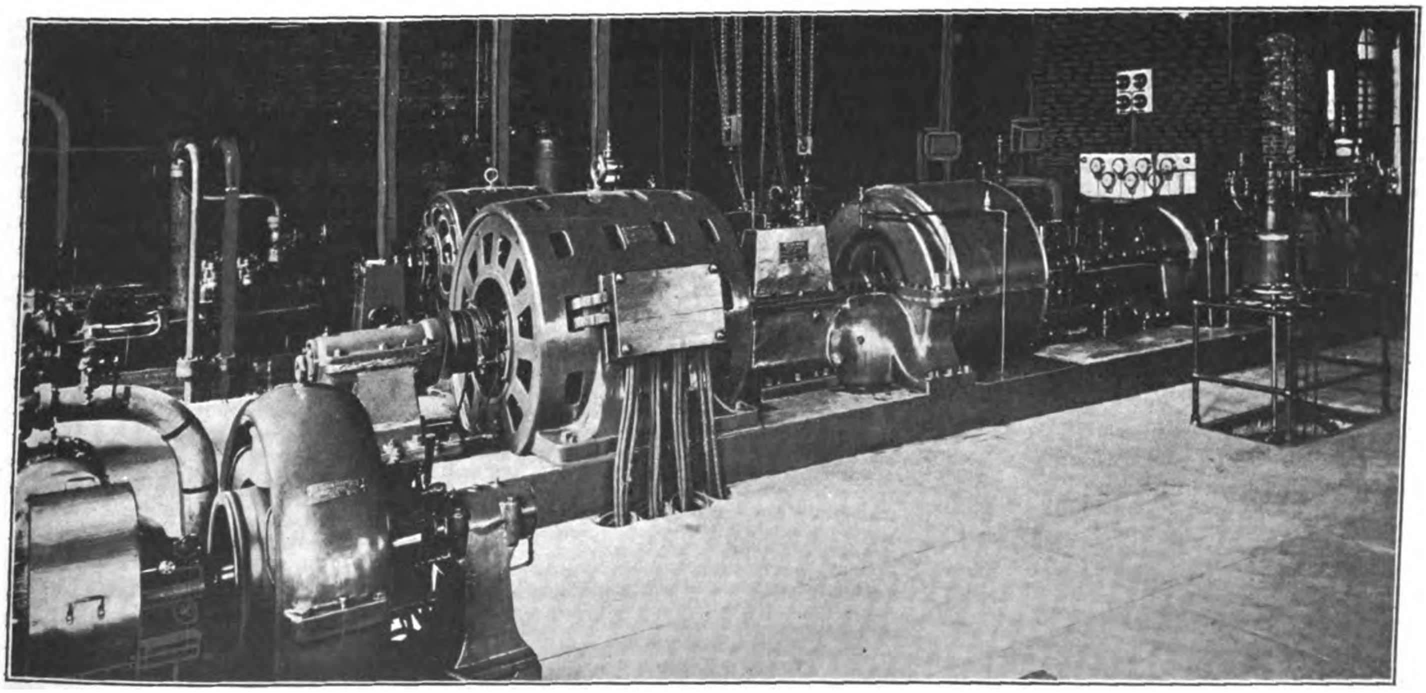


FIG. 2.—VIEW OF TURBO-GENERATORS FROM GENERATOR END.

The remainder of the load comprises miscellaneous independent and grouped motor drives requiring from 1 to 100 horse-power, with both constant and variable speed. The factory was formerly operated entirely by steam power from several small plants located in the several buildings near the local centers of loads. Simultaneous with the conversion to electric drive, a consolidation of all sources of power into one central power station was effected, which then supplied the steam, water, air, electricity and hydraulic distribution systems, each serving the entire plant or those sections where the particular kind of service was required.

The present power station is located near the center of electrical load, and is completely enclosed by factory buildings so that large extensions are inadmissible. At the time of centralizing the power generating equipment, provision for existing and future needs were made by the adoption of direct-connected generating units and water-tube boilers. The former, however, proved inadequate later on account of unforeseen factory extensions and a type of prime mover still more compact became a necessity, resulting in the choice of steam turbines. The station is divided into two main sections: a boiler room 158 ft. x 80 ft., and an engine room 122 ft. x 50 ft., the latter having a wing 29 ft. x 36 ft. for accommodating the fire and hydraulic pumping machinery.

It is of interest to observe the actual conditions obtaining in this plant as regards provisions for reserve power. With the turbine machinery the plant has been doubled in capacity without disturbing the arrangement of the old main power units, and it is still possible to increase the plant by 80 per cent and yet retain the two principal reciprocating engine units of the original plant. The present reciprocating engine and generator equipment, aggregating 1250 kw. capacity, occupied 2630 sq. ft. of floor area, including liberal passageways, or 44 per cent of the total, equivalent to 1.7 sq. ft. per electrical horse-power. The turbine plant occupies 980 sq. ft., or 16 per cent of the total, which is equivalent to 0.64 sq. ft. per electrical horse-power, or a little over ¼ that necessary for engine units of equal capacity. The remaining 40 per cent of floor space is required for the switchboard, rotary converters, exciters, a lighting unit, air compressors and hydraulic accumulators.

The steam turbine plant consists of two units, one of 400 and the other of 750 kilowatts capacity, both of the Westinghouse parallel flow type. The smaller turbine is a single cylinder, and the larger a double-cylinder machine. Both turbines are direct connected through semi-flexible mechanical couplings to alternating-current generators, which are arranged so as to be connected in parallel with the three engine-driven generators. The smaller turbine operates at 3600 r.p.m., and the larger at 1800 r.p.m. An overload capacity of 50 per cent is provided by means of by-pass valves at the side of the turbines; these also enable the machines to carry full load continuously should the condensing system break down.

Not the least interesting feature of this plant are the foundations. In the case of the 400-kw. unit no foundation was constructed, the turbine being supported partly upon a brick wall, formerly used for the former building foundation, and partly upon I-beams spanning the condenser pit. This unit rests directly upon the power house floor. The 750-kw. unit rests at the four corners upon four brick and concrete piers, 12 ft. high, and battered from a width of 2¾ ft. at the top to 4 ft. at the bottom. An 8-ft. passageway between the piers provides access to the receiver and piping. The condenser pit is spanned by two 12-in. I-beams, one under each side of the bed-plate, which is continuous and provided with longitudinal and transverse ribs for rigidity. Approximately 12 per cent of the area of the bed-plate constitutes the area of support of the piers, the remainder that of the steel beams, which are reinforced by struts at the center to prevent flexure.

Both turbines operate condensing in conformity with the remainder of the plant, and are connected to a single condenser located immediately beneath, in a concrete-lined pit. The condenser is of the Worthington surface type, designed for high vacuum, and rests upon concrete piers in a pit 9 ft. x 17 ft. 7 ins., and 9 ft. deep, the pit being extended 14 ft. on a level with the lowest tubes to permit the removal of the head for inspection of tubes. Two vertical outlets communicate directly with the exhaust outlets of the turbines through gate valves and corrugated copper expansion joints, the latter being required to prevent distortion of the turbine shell by longitudinal expansion and contraction of the vertical exhaust piping. Horizontal outlets from tees in the exhaust risers communicate with automatic relief valves, which in turn discharge through risers leading to the roof. The condenser steam collecting in the condenser hot-well is drawn off by a duplex steam pump and returned directly to the boiler feed line.

The circulating water is furnished by a 14-in. Worthington annular volute centrifugal pump driven by a 9-in. x 8-in. Westinghouse Junior engine normally at 320 r.p.m. Both the suction and the return from the condenser are water-sealed beneath the surface of an intake well located in the basement of the pump room and communicating by means of a 33-in. tunnel with a canal passing in the rear of the power house. Thus the two condenser water legs are hydraulically balanced.

A feature of the condensing system is the arrangement for cooling and abstracting saturated air. For this purpose a tubular vapor cooler is located in the lower part of the condenser head directly in the path of cold circulating water entering the condenser. A 6-in. and 12-in. x 12-in. rotative dry air pump located beside the turbine foundation is piped through this vapor cooler to the condenser shell, thus serving to remove the vapor collecting in the top of the shell. In passing through the cooler the moisture condenses and the dry air is drawn off by the air pump. With this separation of the functions of dry and wet pump each may be better adapted to their respective duties, resulting in more effective performance and higher vacuum.

Saturated steam is furnished to the turbines at 150 pounds pressure from Stirling water-tube boilers, all fired by mechanical stokers. The remainder of the boiler plant consists of 72-in. return-tubular boilers, likewise stoker-fired; three furnish steam to the auxiliaries and to the various buildings for heating and other uses.. A complete coal handling apparatus is used. The coal is delivered to the station in hopper cars which are run in on a siding beneath the coal tower and the fuel is discharged into a hopper located beneath the center of the track. It is then elevated by a Hunt bucket conveyor to a capacious overhead steel bunker extending the length of the boiler room, whence it is drawn as required through steel chutes which discharge directly into the stoker hoppers. The weight of fuel consumed by the generating plant is separated from the total by means of weighing chutes operating upon an elevated track above and in front of the boilers. Pittsburg slack coal is generally used. Ashes are removed from the stoker ash pits through a capacious tunnel extending beneath the floor the length of the boiler room. The coal conveyor returns through this tunnel and makes an independent loop around an elevated ash bin in the yard located immediately over the loading hopper. By this arrangement coal may be delivered and ashes discharged simultaneously.

The high-pressure steam piping is assembled with rolled steel flanges peened over. The branches to the turbines consist of long radius pipe bends, thus allowing for expansion and contraction without the use of expansion joints. The 12-in. main leading to the turbines rises from the 16-in. engine main at its middle point and parallels it at a short distance above to the end of the boiler room, when both drop 25 feet and continue beneath the engine room floor. Separators are inserted in both the engine and the turbine steam lines, located at the lowest point in the piping and drained by steam traps.

The electrical plant comprises generating machinery aggregating 2400 kilowatts and about 4000 horse-power in motors, divided in the approximate ratio of 3 to 7 between direct-current variable speed and alternating-current constant speed motors, respectively. The entire generating plant is two-phase, furnishing current at 220 volts and 60 cycles to one switchboard, from which part is delivered directly to the alternating-current distribution system and part converted into 320-volt direct current by two 200-k.w. rotary converters, which supply a three-wire direct-current distribution system.

The switchboard is of standard Westinghouse design, comprising 20 panels each devoted to a single machine, feeder, or group of feeders. Each of the heavy feeders occupies a single panel containing a wattmeter, a switch in one leg, and a circuit-breaker in the other. Opposite ends of the rotary converters occupy separate panels, thus avoiding confusion of alternating and direct-current apparatus. Series transformers in the bus-bar and machine leads permit the use of low voltage ammeters upon the board; these are of the round dial type. In order to decrease the bus-bar section all heavy feeders draw their supply of current from the bus-bars at a point very near the generator connections. Moreover, the rotaries are connected at one end of the bus-bars and the small feeders at the other, which tends toward a uniform "tapering" of current along the bus-bars. Synchronizing lamps are employed for paralleling the generators.

Three-wire balancing coils are used on the direct-current system for variable-speed motor work. A typical diagram of the system is shown in Fig. 7, giving the elementary rotary connections. It will be observed that no special apparatus is required for the three-wire system outside of the two balance coils, which are simply single-coil transformers mounted in standard transformer cases and located at any convenient place; in this case they are suspended from the basement ceiling. The rotaries are standard Westinghouse machines in every particular.

Throughout both the alternating and direct-current distribution systems secondary bus-bars have been installed in buildings where considerable power is required. The buildings are usually divided into five independent sections, each served by secondary bus-bars. These are fed by heavy cables carried from the main switchboard through a system of tunnels used in common with the remaining distribution systems for water, air, steam, signals, etc. In cases of specially concentrated loads, such as occasioned by the 200 and 300-h.p. motors, special feeders are run from the power house in order to secure better voltage regulation on the remainder of the distribution system.

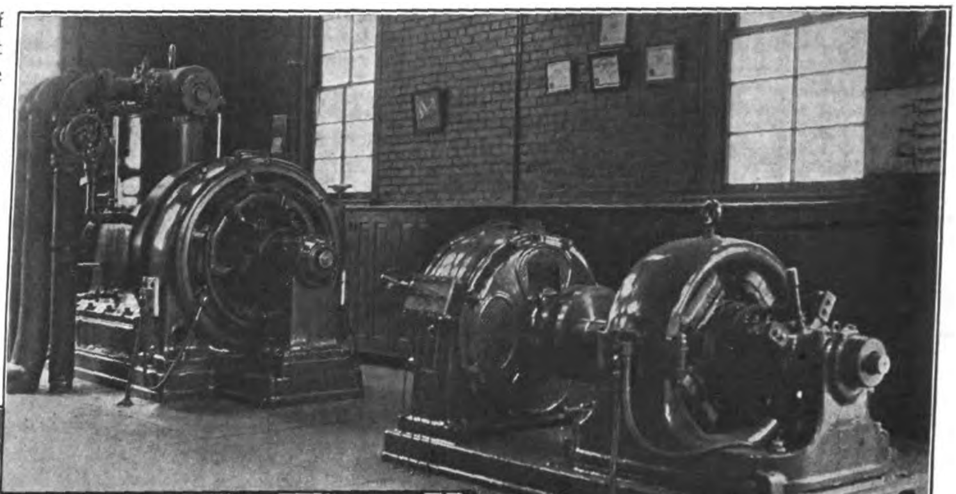


FIG. 4.—EXCITER UNITS.

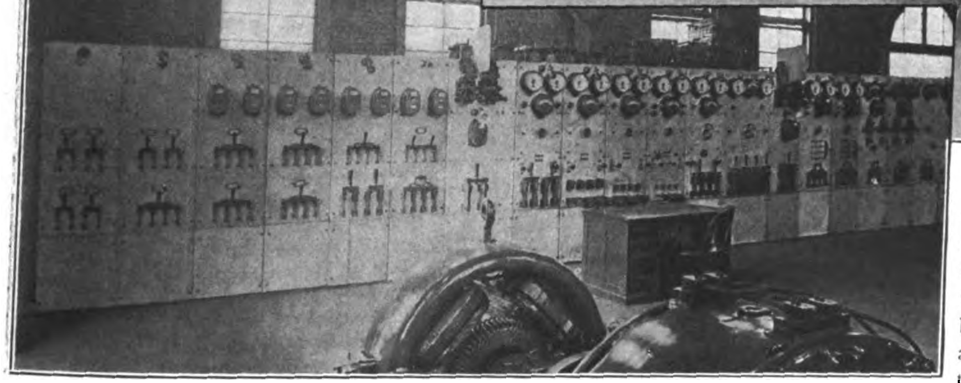


FIG. 3.—VIEW OF MAIN SWITCHBOARD.

The list of motors includes about 112 induction motors, five of which are of 300 horse-power each, 13 direct-current variable speed machines, five of which are of 100 horse-power each, and several induction motors arranged with automatic control for operating freight elevators. Many of these machines are used for driving special machinery peculiar to the manufacture of rubber products, which in many instances have been developed or improved by the Goodrich Company's experts and are hence not illustrated. The motor drives are, however, in the majority of cases of the simplest character. For group-driving the motors are generally bolted to the ceiling and belted directly, or through a short countershaft if necessary, to sectional line shafts. A similar arrangement is employed in the machine and wood-working shops for driving shop tools. There is, however, a considerable amount of special machinery which it is necessary to drive from beneath in order to preserve clear head room above the operating tables. In these cases the motors are either mounted on the floor beneath the tables or attached to the ceiling below, and some form of transmission gear employed. In cases where plenty of room is available, rubber belting is used, but in restricted locations, such as floor drives, Morse or Renold silent-chain gear is employed, these being partially or entirely enclosed in sheet iron cases according to their liability to become clogged with dust or grit.

In a few instances variable speed with inverse torque is obtained by means of an adjustable pulley. Thus an expressing machine is served by a 10-h.p. induction motor running at 840 r.p.m. and mounted upon the floor level. It is geared through a Renold silent chain to a Reeves variable-speed pulley; the chain gear effects a speed reduction of 4 to 1 and a speed ratio of 40 to 12 is secured by the Reeves pulley with the maximum torque at the commencement of the expressing process.

The large induction motors of 150 to 300 horse-power are geared with a ratio of 5 to 1 directly to massive crude rubber rolls; one motor being usually located between two rolls which it drives. A standard starting box is used as in the case of the smaller motors. In order to prevent sudden overloading of the power station due to the simultaneous starting of a number of the larger motors, a simple signal system has been put into use. The system consists of whistle alarms located near the 300-h.p. motors and supplied from the compressed air system; they are operated by a magnet controlled by a push-button on the switchboard. By this system the switchboard attendant is able to notify the motor attendant when the load upon the power house is so heavy as to necessitate the placing in operation of an additional generator to carry the increase. A similar device controlled by the motor attendant is used to warn the power house of an increase of motor load.

The large direct-current motor drives are of interest by reason of the variable speed features. The motors driving calendar rolls are installed in a concrete pit and geared to the rolls through a heavy Morse silent chain reduction gear; further speed reduction is accomplished by massive spur gearing. The motors are of 100 horse-power capacity, and each is provided with a standard controller located in front of a motor panel containing switches, a circuit-breaker and indicating instruments. The controlling outfit is located close to the rolls so that prompt control of the process is possible. The controller has 9 points, giving 18 different speeds with the two voltages available upon the three-wire system, namely, 160 and 320. Resistances in both the armature and shunt field circuits are employed to effect the proper gradation of speeds, which range from 100 to 500 r.p.m.

Current for lighting the entire works is taken from a two-phase distribution system supplied directly from the power station bus-bars in order to render the illumination independent of the local fluctuations due to motor load. The distribution is on the familiar three-wire plan, 110-volt lamps being used between each 220-volt lead and a neutral wire. This neutral is connected to the central point of an auto-transformer or balancing coil which preserves approximately equal voltage on the two sides. During Sundays and holidays, when the main plant is shut down, a small 125-volt direct-current generator supplies the lighting mains.

A most interesting feature of the plant, as a whole, is the harmonious operation of the two different types of prime movers in parallel, and the ease and accuracy with which a definite sub-division of load may be pre-determined. The turbine machinery being installed last, was necessarily obliged to conform in all respects to the conditions already existing in the engine plant. The turbine governors were designed for a definite sensitiveness, which proved to be somewhat greater than that of the engine governors, with the result that the burden of a sudden load would fall upon the turbines and cause a momentary checking in speed. This action produced a more or less severe "surging" between the two parts of the plant, but this effect was easily eliminated by cutting out of service a number of coils of the turbine governor spring by means of a special nut mounted upon the governor sleeve, the adjustment of which determines the sensitiveness of the governor in responding to sudden load changes. The turbine governors have been adjusted so that the turbine plant assumes somewhat more than its share of load during fluctuations, which is permissible on account of the high inertia and uniformity of speed of the rotating parts. The effect is further distributed between the two turbines in inverse ratio to their respective capacities.

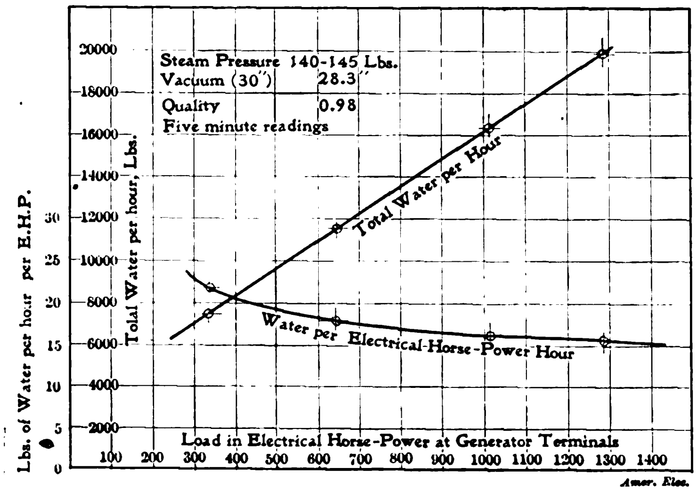


FIG. 5.—CHART OF TURBO-GENERATOR PERFORMANCE.

The adjustment for steady loads is quite distinct from that for fluctuating loads. The former is a question of spring tension, and the latter of spring stiffness. The tension adjustment may be made while the machine is running, as the spring mount is attached to a sleeve surrounding the governor spindle and working between ball bearings. This tension adjustment enables any divisions of load to be secured; it may also be used for synchronizing. In practice, however, this is accomplished by a simpler method. The speed of the turbine is brought a little above that of the engines already running, so that a slow blinking of the synchronizing lamps is observed; then by resting one's finger lightly upon some part of the governor mechanism, the speed may be brought down sufficiently to produce absolute synchronism for as long a period as desirable—even as long as one minute if the load happens to be steady. By this means the tension adjustment need never be changed, as the slight excess in speed necessary to synchronize is not appreciable when the machine is under load. In this plant the large turbine is usually given more than its share of load, owing to the controlling influence exerted upon the engine plant. Sudden loads which would perceptibly check the engines prove imperceptible in the case of the turbines.

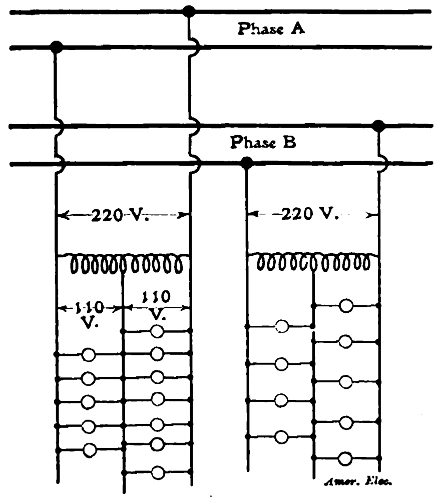


FIG. 6.—BALANCING COILS FOR ALTERNATING-CURRENT DISTRIBUTION.

The foregoing information regarding the Goodrich plant is made public through the kind permission of the B. F. Goodrich Company and the Westinghouse Machine Company, builder of the turbines; the Westinghouse Electric & Manufacturing Company, who installed the entire electrical plant, has our thanks also for assistance in obtaining data.

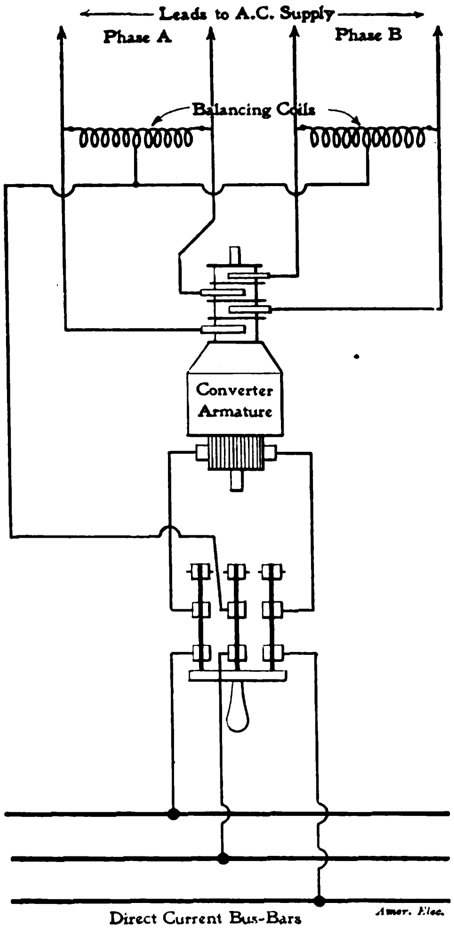


FIG. 7.—BALANCING COILS FOR DIRECT-CURRENT DISTRIBUTION.

TELEPHONE ENGINEERING.

Aerial Cable Lines.

BY F. J. DOMMERQUE.

The advantages of aerial cable lines over open wire lines have been mentioned repeatedly in previous articles; also pole lines and cables that form part of such lines have been discussed, but it remains to give an account of the manner in which the cables are attached to the pole line and how the connections of the cables are made to terminals.

The mechanical properties of cables do not permit of stretching the cables from pole to pole like open wires. Means have therefore to be provided to hang the cables. The usual means are either steel wires or steel wire strands, which are strung from pole to pole and from which the cables are supported by so-called cable clips or hangers, or by a continuous marlin cord.

The steel wire or strand has obtained the name "messenger." A galvanized steel wire messenger can be used advantageously for small cables, and for large cables in very short spans. For large cables generally, however, a stranded messenger consisting of seven galvanized steel wires twisted together is required. Where a considerable amount of aerial cable is used it pays to do a little figuring, as considerable saving may be effected by using different sizes of mesesngers corresponding exactly to the weights of the cables to be supported, and taking into account the length of span. The weights of the different cables have been stated in the description of cables. By the aid of this information and the following explanation and tables, it will be easy to determine the size of messenger that should be used.

TABLE I.—SUPPORTING CAPACITY OF DOUBLE GALVANIZED NO. 4 STEEL WIRE.

Length of span.	Weight of the cable that can be supported.
80 feet	1350 lbs. per 1000 feet
90 feet	1184 lbs. per 1000 feet
100 feet	1050 lbs. per 1000 feet
110 feet	946 lbs. per 1000 feet
120 feet	851 lbs. per 1000 feet
125 feet	811 lbs. per 1000 feet
130 feet	774 lbs. per 1000 feet
140 feet	709 lbs. per 1000 feet
150 feet	650 lbs. per 1000 feet
175 feet	536 lbs. per 1000 feet
200 feet	450 lbs. per 1000 feet

For a steel wire messenger a No. 4 B. W. G. wire may be employed economically. This wire has a diameter of 238 mils, a weight of 149 pounds per 1000 feet, and a breaking weight or ultimate tensile strength of 4500 pounds. When buying such wire, it should be stated in the order that the wire must have the above specified ultimate tensile strength, also that the wire should be capable of elongating 3 per cent without breaking. In addition, the order should contain the usual specification for double galvanizing and provision against mechanical imperfections as alluded to in a previous article on "Wire," principally with respect to freedom from scale, flaws, splits, cold shuts and such features as may be detrimental to the advantageous employment of the wire. The supporting capacity of this wire can be determined from Table I, which is calculated for a factor of safety of three and a deflection of 1 per cent of the span.

A 25-pair No. 22 B. & S. G. aerial cable weighs 900 pounds per 1000 feet; from the table it will be seen that a No. 4 steel wire would support such a cable over a span of 115 feet, as 900 in the table is about midway between 946 for 110 feet and 851 for 120 feet.

Table II, for strands, is also based on a factor of safety for three and a deflection of 1 per cent of the span. In localities where the cables are exposed to very high winds and severe sleet storms, it may be advisable to use the next diameter larger than the one found in the tables.

It will be noticed that only stranded wire of 5/16" diameter and above is mentioned. Smaller sizes have the disadvantage that the individual wires composing the messenger become too fine and would rust through quickly at such places where the galvanizing might be defective. For the same reason it is sometimes advisable to use an ordinary steel strand instead of a special (Siemens-Martin or high-strength or extra high-strength) steel strand so as to obtain a larger diameter of the individual wires. Ordinary steel, which in reality is mild steel, is also more pliable and therefore easier to handle. As far as the cost of the strand itself is concerned, there is not much choice between the different qualities, for the better the quality the higher the price. The prices per 100 feet range about as follows:

Diameter of strand.	Gauge of wires.	Ordinary steel.	Siemens-Martin.	High strength.	Extra high strength.
½ in.	No. 8	$2.10	$2.70	$3.95	$5.50
7/16 in.	No. 10	1.70	2.20	3.45	4.60
⅜ in.	No. 11	1.35	1.75	2.70	3.55
5/16 in.	No. 12	1.08	1.30	2.10	2.70

Table II.—Supporting Capacity of Double Galvanized Stranded Messengers.

Material of strand.	Diam. of strand. Inch measure	80	90	100	110	120	125	130	140	150	175	200
		Weight per 1000 ft. of the cable that can be supported.										
Ordinary steel	½	2273	1990	1708	1507	1332	1265	1196	1074	969	758	599
	7/16	1550	1330	1168	1029	913	862	815	731	658	513	404
	⅜	1260	1088	946	834	740	700	661	593	534	417	328
	5/16	910	785	689	604	536	506	479	430	386	302	238
Siemens-Martin steel.	½	3146	2740	2412	2146	1924	1826	1736	1574	1435	1156	946
	7/16	2640	2300	2040	1821	1640	1559	1486	1354	1240	1011	840
	⅜	1976	1710	1522	1358	1220	1160	1104	1004	918	746	520
	5/16	1410	1230	1086	968	870	826	788	715	654	530	438
High strength steel.	½	5480	4820	4280	3842	3480	3318	3172	2908	2480	2222	1880
	7/16	4640	4090	3640	3276	2973	2841	2710	2497	2306	1926	1640
	⅜	3543	3110	2776	2497	2265	2163	2060	1900	1754	1462	1243
	5/16	2490	2190	1950	1753	1590	1517	1451	1332	1230	1042	870
Extra high strength steel.	½	8480	7480	6680	6023	5480	5237	5018	4622	4280	3592	3080
	7/16	7140	6300	5640	5094	4639	4441	4245	3925	3639	3069	2640
	⅜	5460	4810	4310	3891	3543	3388	3248	2995	2776	2339	2010
	5/16	3823	3370	3016	2723	2478	2371	2271	2094	1940	1634	1403

(Span in feet.)

These prices are for double-galvanized strand and no other should be used. When estimating on the cost of strand in place, the freight must be added to the above prices, as these are on board cars at the factory. One hundred feet of ½-in. strand weighs approximately 52 pounds; of 7/16-in. strand, about 36 pounds; of ⅜-in. strand, about 29 pounds, and of 5/16 in. strand, about 21 pounds.

There is no need for having splices in strands, as they come in long lengths from the factory. A reel of ½-in. strand contains about 5000 feet without splices; a reel of 7/16-in. about 7000; of ⅜-in. about 9000, and of 5/16-in. about 10,000 feet without splices.

The following form may be used in ordering stranded messenger wire:

Gentlemen:

Under the conditions hereinafter specified, please deliver the following enumerated double-galvanized messenger strands free on board cars at freight depot in ....
....reel, marked.............
containing.................feet of ½-in. (or whatever the size may be) messenger strand, composed of seven No. 8 B. & S. gauge (or whatever the corresponding gauge may be) mild steel (or Siemens-Martin, high strength, or extra high strength) at quoted price of..per 100 feet. ....reel, marked
......................, containing, etc., etc.

Each strand to be uniformly spiraled throughout and to have a uniform diameter over its entire length without any loose places anywhere. The piece on each reel to be continuous, without any joints or splices.

Each individual wire in each strand to be free from imperfections and double galvanized, so as to stand a test of four immersions in a saturated solution of sulphate of copper, each immersion lasting about 70 seconds (the wire to be wiped dry between immersions), without showing any copper deposits.

If one or more defective places in a reel are found, we reserve the right either to reject the whole reel or to use as much of the reel as we may select, without notice to the manufacturer, deducting the unused portion from the bill. The rejected strand will be held subject to your orders, pending an answer to our notification; if you so desire, we will then entertain a proposition to use the rejected strand for guying, after cutting out the defective places.

Respectfully yours,
.................................Telephone Company.

There are formulas by which the deflection that should be given to the messenger before the cable is hung on it can be determined, but in actual practice the messengers are pulled up to the proper sag under the supervision of a foreman who by experience has become accustomed to judge how tight the messenger should be pulled up in order to give it a presentable appearance when the cable is suspended from it.

In an 80-foot span the sag may vary from 6 to 10 inches; in a 100-foot span, from 9 to 15 inches; in a 120-foot span, from 13 to 21 inches, and in a 200-foot span, from 37 to 49 inches, according to temperature, size of strand and cable, and tension.

The deflection of the messenger should be so regulated that at the lowest possible temperature the strain in the messenger is not more than one-fourth of the breaking strain. In calculating the proper deflection for a messenger, this lowest temperature is the starting point, and since it varies according to climatic conditions it is impracticable to calculate a set of tables applicable to all spans and sizes of messengers.

As mentioned before, an experienced and reliable foreman will take care of the messengers in ordinary cases. However, there may be extraordinary cases like very long spans or lines that are exposed every winter to a heavy wind pressure and a thick coating of ice. In such case the foreman cannot rely upon his wits exclusively, and he has to be assisted by some calculations. These calculations can also be recurred to in the case of ordinary spans, for which a table of deflections was given in the article discussing the erection of pole lines. At that time it was mentioned that although the curve into which a suspended wire formed itself was mathematically a catenary, it could, for all practical purposes, be considered a parabola; it will be considered so now, as it will facilitate calculations. Without going into mathematical deductions, the following relations exist between the various factors in the problem. If

T = tension (maximum) on the wire in pounds,
L = length of span in feet.
d = deflection of wire at center of span in feet,
W = load between supports in pounds;

then $T = \frac{L\,W}{8\,d}$; so that

$$d = \frac{L\,W}{8\,T}.$$

This formula gives the deflection at the lowest temperature. For a No. 4 messenger, the dip or sag at the lowest temperature for an 80-foot span will then be:

$$d = \frac{80 \times 0.149 \times 80}{8 \times \dfrac{4500}{4}} = 0.106 \text{ foot}$$

$$= 1\frac{9}{32} \text{ inches.}$$

By "lowest temperature" is meant the lowest one ordinarily encountered, as the factor of safety of four takes care of extreme cases. The factor four, however, does not take care of heavy wind pressure and the load put on the messenger in locations exposed to such climatic conditions. Assumptions have been made with respect to the additional weight put upon wires by wind and ice, but the best way out of all such difficulties is to increase the factor of safety with increasing severity of climate; going as far as eight in the most exposed and inclement regions.

In the above calculation no cognizance was taken of the fact that the messenger has to carry the cable; in order to take care of this, the weight of the cable must be added to the weight of the messenger in the calculations. In the formula for the sag of No. 4 wire at the lowest temperature and for a span of 80 feet, the value 80 (0.149 + 0.9) = 83.9 pounds must be inserted instead of 80 × 0.149 pounds, and the sag at the lowest temperature becomes:

$$d = \frac{80 \times 83.9}{8 \times \frac{4500}{4}} = 0.746 \text{ foot} = 9 \text{ ins.}$$

(in round figures).

The next problem is to calculate the sag for any temperature from the sag for the lowest temperature. For this purpose, ascertain first the actual length of the wire between the two supports. Let this length be denoted by L'; then

$$L' = L + \frac{8\,d^2}{3\,L};$$

whence

$$d = \sqrt{\frac{3\,L\,(L' - L)}{8}}$$

Now calculate first L' for the lowest temperature; then calculate from this value L' for any desired temperature, remembering that the coefficient of linear expansion for each degree Fahrenheit equals

0.000,006,6 for steel,
0.000,006,8 for iron,
0.000,009,5 for copper,
0.000,016 for lead.

Having found L' for the lowest temperature, multiply it by 1 + the coefficient of expansion × the difference in temperature to obtain its value at the other temperature. For the No. 4 messenger, this gives:

$$L' = 80 + \frac{8 \times 0.746^2}{3 \times 80} = 80.0185 \text{ feet.}$$

Assuming the lowest temperature to be 10 degrees below zero, and the temperature at the time of erection of the messenger to be 60 degrees above, then the value of L' at this new temperature would be

$$80.0185 \times [1 + 0.000{,}006{,}6 \times (10 + 60)] = 80.055 \text{ feet.}$$

From this the required deflection becomes:

$$d = \sqrt{\frac{3 \times 80\,(80.055 - 80)}{8}} = 1.29 \text{ feet} = 15 \text{ inches.}$$

This is a rather excessive sag and a stronger messenger would be advisable.

◆ ◆ ◆

ELECTRIC MOTORS FOR CENTRIFUGAL PUMPS AND FANS.

BY AUG. J. BOWIE, JR.

The problem of determining the proper capacity of a motor to drive a centrifugal pump is not always easy to solve. The solution is too often the result of guess work, and is liable to be seriously in error. In the case of direct-acting pumps working against a known head, the proper motor capacity can be easily calculated. The most economical size of motor for the purchaser, however, may not be solely determined by the possible loads, and their duration, which the motor may be called upon to carry. Particularly is this true where a flat rate system is in vogue and where power is purchased at a price depending upon the rating of the motor and not upon the power actually used. This system of charging for power leads to great abuse in the underrating of motors; on the other hand, it may work a great hardship on a purchaser of power who innocently uses a motor far larger than is necessary and pays for power that is not consumed. Where measurements of power are taken as a basis for determining the flat rate, such measurements should be taken under the average running conditions. A variation in these conditions may lead to a very erroneous system of charges in the case of centrifugal pumps and fans, as will be seen later.

For centrifugal pumps and fans the power required for operation at a rated speed and head is by no means all that need be known. One should also know the maximum load which can ever come on the motor when driving the pump or fan at the rated speed and under any possible head. This maximum may be far in excess of the rating.

The problem in the case of centrifugal pumps and fans will be treated under the following three heads: (1) Constant speed and varying heads; (2) changing speed with head varying directly as the square of the speed; and (3) constant head and varying speed.

Constant Speed.—The following treatment applies equally well to centrifugal pumps and to centrifugal fans, as the same laws govern the flow of either fluid, but pumps alone will be considered. Represent by H the head generated by the pump, which is equal to the difference between the discharge and suction pressures, plus the difference between the discharge and suction velocity heads. Represent by Q the cubic feet of water discharged per minute. The general equation expressing the relation between Q and H is, $H = A - BQ^2 + CQ$, where A, B and C are constants. This is the equation of a parabola, and it will approximately represent the actual curves obtained in practice. Back-slippage through the running wings of the pump has not been taken into account in the above equation, and will account in part for discrepancies between theoretical and actual results.

The pressure exerted by the pump is a maximum when $2\,B\,Q = C$, and $Q = \frac{C}{2\,B}$; in which case $H = A \div \frac{C^2}{4\,B}$. If W_0 = output of pump in watts, $W_0 = KHQ$, K being a constant. $W_0 = KQ(A - BQ^2 + CQ)$, and this is a maximum when

$$Q = \frac{C}{3\,B} \pm \sqrt{\frac{A}{3\,B} + \frac{C^2}{9\,B^2}},$$

corresponding to $H = \tfrac{2}{3}A + \tfrac{1}{3}CQ$. In some pumps the constant C is so small that it may be disregarded. In this event the maximum head is obtained at zero discharge and is equal to A. The maximum output of the pump is obtained at a head of $\tfrac{2}{3}A$. The relative values of C and B determine the nature of the output curve of the pump and the maximum obtainable pressure. If B be fixed, the greater value of C the greater will be the capacity of the pump. If C be fixed, the smaller the value of B the greater will be the pump capacity. However, the relative values of C and B will have a very important bearing on the ratio between the maximum power required to run the pump, and the power required to run it at the point of highest efficiency, or at the point of maximum output.

The quantity $\frac{C}{B}$ is influenced largely by the angle which the vanes of the pump make with the radial at the external periphery, as well as by the width of the face of the runner. However, it is beyond the scope of this paper to enter into a discussion of the design of pumps, other than in a general way so as to show the effect of the design upon the maximum power required to drive the pump. Usually this power will increase as the effective head of the pump decreases. This would naturally be expected as long as the energy output of the pump is on the increase, but after the latter starts to decrease it might be considered natural to look for a decrease of the driving power. However, when B is fixed, the smaller the value of C the less will be the tendency of the pump to require additional power to drive it at heads lower than its rated capacity, and the higher the value of C the greater will this additional power become. When C is fixed, the reverse holds true for B.

A centrifugal pump, when operated at too low a head, shows a very low efficiency. In general, however, with a well-designed pump, the range of efficient operation for a constant speed is fairly broad. The principal point which the writer wishes to bring out in this connection is the danger of overloading a motor by reason of too low a head. A manufacturer will usually guarantee a certain efficiency and input for a pump at its rated load, but will say nothing concerning the power required to drive it at heads lower than that called for. The question may arise, why not give a pump the proper speed for a given head? This is frequently impracticable, since pumps must often be installed to work under widely varying heads, where it is not an easy matter to change the speeds. Often the heads at which the water must be elevated may vary practically from zero to the maximum head against which the pump will deliver. In some cases these overloads may be of long duration, and a sufficiently large motor should be installed. On the other hand, the maximum load will often be only of short duration, as for example, when pumping from a well, particularly where there is a pit in connection with it, which is partially filled up with water. Generally it will not take the pump long very decidedly to lower the water, and the duration of overload will be brief.

The behavior of centrifugal pumps may be represented very completely by four curves. These curves are based upon an absolutely fixed speed, but corrections for variations from this speed may be made without difficulty. All four curves have for abscissæ the volumes of the fluids delivered in a fixed time interval, while for ordinates they have, respectively, head, watts input to pump, watts output from pump, and pump efficiency. The last two curves determine the proper rating of the pump. In general, the maximum efficiency occurs before arriving at the point of maximum output. The proper rating is somewhat indefinite, as will appear from the appended curves obtained in practice. The natural tendency of a manufacturer is to rate his pumps as high as possible. Still, he does not care to go far beyond the point of maximum efficiency at the full load rating.

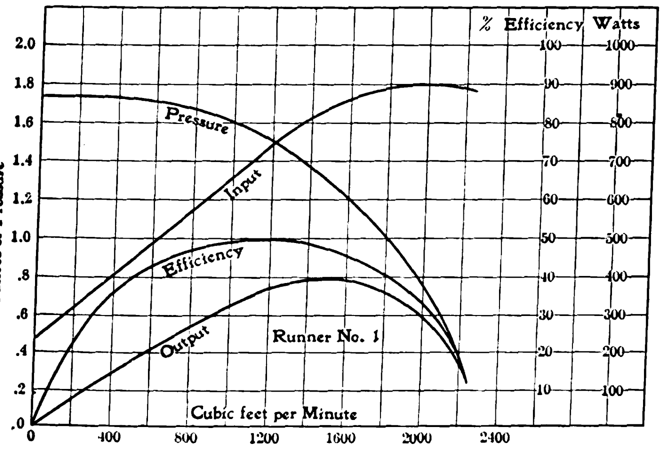


FIG. 1.

The accompanying curves show the results of tests on two fans with the same casing, but with different runners. In the first set (Fig. 1) $\frac{C}{B}$ is smaller than in the second set (Fig. 2). According to the curves, the first fan is of smaller capacity, but of higher efficiency than the second. Particularly noticeable is the curve of watts input, which in the first case shows a decided concavity towards the horizontal axis, shortly after passing the maximum output of the pump. In the second case (Fig. 2) the corresponding curve, on the contrary, becomes slightly convex towards the horizontal axis, and requires far more power under low heads. Thus the ratio of maximum outputs is 1.15, and the ratio of maximum inputs, within the range of the tests, is 1.68. These fans represent by no means extreme conditions. If the second fan should be called upon to operate under the lowest head tested, and if it were rated at the point of maximum efficiency and a corresponding motor were installed, then this motor would be liable to an overload of 89 per cent.

Changing Speed with Head Varying as the Square of the Speed.—If a centrifugal pump delivers Q cubic feet of water per minute, against a pressure of H feet while running at R revolutions per minute, and then if the speed be altered to $R' = K\ R$, it will deliver $Q' = K\ Q$ cubic feet per minute against a pressure $H' = K^2H$ feet. If W_0 = watts output of pump in the first case, and Wi = watts input to pump, then $W_0' = K^3W_0$, and $Wi' = K^3Wi$.. These equations follow from the proportionality between the head produced and the square of the speed, and because, when the volumetric output varies directly as the speed, the relative angles of motion of the water are not altered. Furthermore, all frictional losses vary as the cube of the speed, and all volumetric leakage losses vary directly as the speed. Hence it follows that increasing the speed of the runner, where the effective head varies as the square of the speed, will result in increasing the capacity of the pump directly as the speed, and increasing the power input and output directly as the cube of the speed. The conditions presupposed in this case, namely that the head varies as the square of the speed, is the condition which exists in the case of ventilating fans, where the head is used up in friction in the pipe, and in the velocity head of discharge from the pipe. This velocity head and also the friction head vary as the square of the discharge from the pipe.

What affects the motor capacity particularly is the fact that the power varies directly as the cube of the speed. Hence the I^2R loss in the armature varies as the sixth power of the speed.

Constant Head.—This is the condition which exists when pumping against a fixed lift, when the velocity heads lost at entrance and discharge, and when the fractional losses in the pipe may be disregarded in comparison with the lift. In this case, and likewise in Case 2, the characteristic curves of a pump under variation of speed can be obtained from those at another speed by multiplying the quantities discharged by the ratio, K, of the speeds, the pressures by K^2, and the watts input and output by K^3. The efficiencies remain the same.

It is evident that the apparatus in Case 3 will operate at a point situated further along on the curves than that in Case 2; the result being a greater delivery of water, and, usually, a greater input to the pump. In general this input will vary faster than the cube, and not as fast as the fourth power of the speed. As an approximation, say, as the 3½ power of the speed. This makes the I^2R loss in the armature vary as the seventh power of the speed. Thus 10 per cent increase in speed represents 40 per cent increase in power and 96 per cent increase in the I^2R loss in the armature. From this it may be seen what an extremely large effect speed variation has on motors driving centrifugal apparatus. There is perhaps no other form of apparatus so sensitive to change of speed in its power consumption. The effect which a steady pump load has in holding the voltage constant by preventing the racing of generators is thus explained.

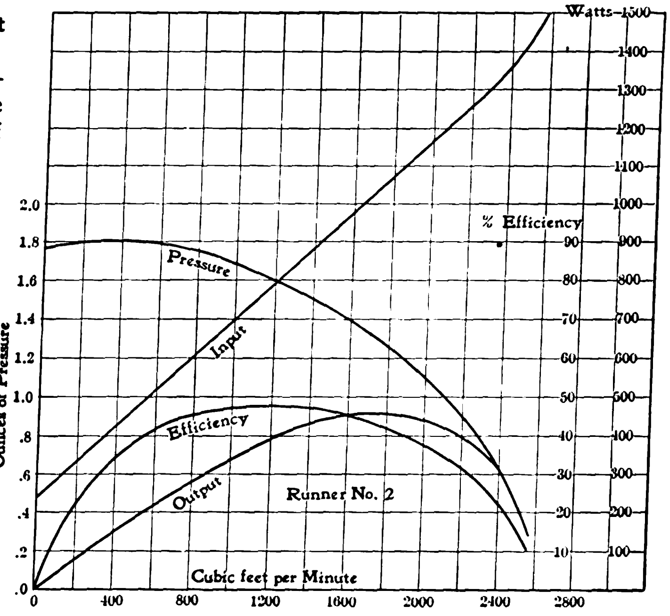


FIG. 2.

If centrifugal apparatus is driven by induction or synchronous motors then the speed is practically fixed by that of the prime mover, so that the maximum load for the motor with a given pump or fan is determined.

Speed control of direct-current motors by variation of field resistance has a limited range in practice, and has many points which tend to make it objectionable for the best conditions of commutation. Even at best there will be considerable field distortion at the high speeds. The effect of a load which would increase as the cube of the speed, and even faster, would seem to limit still further the allowable speed variation to be obtained in this manner. In view of these facts it is well to provide a motor of ample size for such work and at the same time to take care that the field rheostat cannot cut in so much resistance as to overload the motor.

As has been shown, the volumetric output of a centrifugal pump varies directly as the rate of revolution. In spite of this fact, many manufacturers rate their pumps at a fixed volumetric output, and publish a list of suitable speeds for different heads under which it may be desired to operate the pump. In some cases the highest speed given in these lists is three, or more, times as great as the lowest speed. Such misinformation leads to a great deal of trouble and cannot be too strongly condemned.

In regard to the statement previously made, that the efficiencies of pumps and fans are independent of the speed, proper changes being made for head and discharge, no consideration was given to the effect of unbalanced runners or of bearing or stuffing-box friction. These would modify the results obtained. Lack of proper running balance is very apt to cause serious loss of power.

[The foregoing is a paper read at the 175th meeting of the American Institute of Electrical Engineers.]

Abstracts from Foreign Contemporaries

Powerful Electromagnets.—The multi-cored electromagnet of M. Camacho consisted of a number of separately wound iron cylinders, which slid one into the other, the windings being capable of being connected up in a number of different ways. When assembled the various tubes of the electromagnet had the same polarity at corresponding ends. Similar in conception, but of proportionately greater power, is a new electromagnet invented by M. de Mare, of Brussels, and described by Émile Guarini in a recent issue of the London *Electrician*. Two electromagnets were constructed, both having the same cross-section. One was of the ordinary type, and the other was of the De Mare type. The difference between the two types of magnets consisted in the method of winding, the conductors in the latter case being drawn through slots in the core.

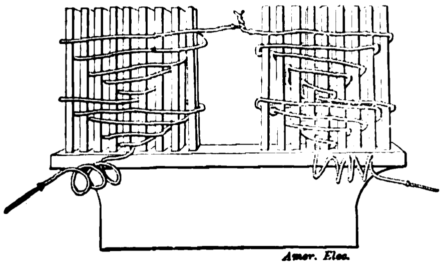


FIG. 1.—METHOD OF WINDING DE MARE ELECTROMAGNET.

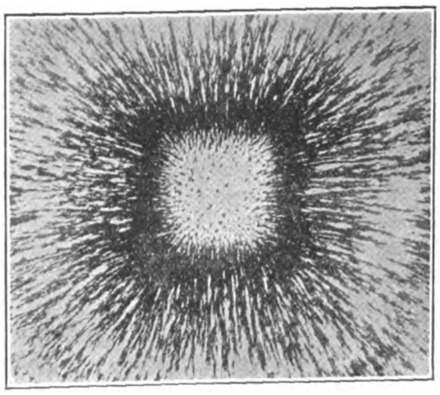


FIG. 2.—FIELD OF ORDINARY ELECTROMAGNET.

The peculiar way in which this winding is carried out is shown in Fig. 1, which represents a wood pattern with a few conductors wound upon it. In the accompanying table some comparative data relating to both forms of electromagnets are given For the same amount of electrical energy consumed, i.e., 8 watts (4 amperes at 2 volts) the carrying weight as measured by a balance was 1050 grammes for the ordinary magnet and 9600 grammes for the De Mare electromagnet, Figs. 2 and 3 show the distribution of the magnetic lines for both magnets from which it will be observed that the lines from the De Mare magnet are much more uniform. According to M. de Mare, even better results are obtained if the windings are completely encased in an iron cover.

Particulars.	Ordinary wound electromagnet.	Electromagnet system De Mare
Total weight	1,010 grs.	1,011 grs.
Weight of copper	220 grs.	220 grs.
Weight of cardboard	20 grs.	21 grs.
Weight of iron	770 grs.	770 grs.
Weight of armature	635 grs.	635 grs.
Length of copper wire	29 m.	29 m.
Diameter of the conductor, bare	1 mm.	1 mm.
Insulation: Double cotton.		
Number of stampings	94	94
Height of built-up core	57 mm.	57 mm.
Width of built-up core	41 mm.	68 mm.
Length of built-up core	40 mm.	47 mm.
Section of core	16.4 cm².	16.4 cm².
Thickness of stampings	4 mm.	4 mm.

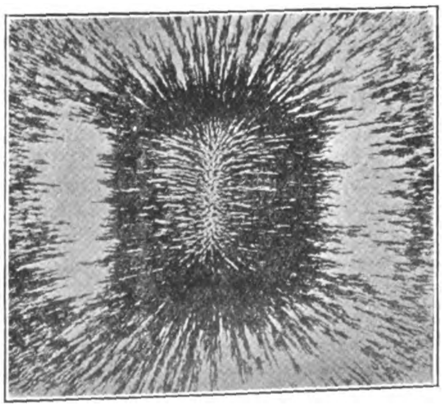


FIG. 3.—FIELD OF DE MARE ELECTROMAGNET.

Substitute for Platinum in Incandescent Lamps.—M. A. Bainville contributed some notes on platinum substitutes in a recent issue of *L'Electricien* which are of interest. The price of incandescent lamps has decreased to such an extent that it has not only been necessary for manufacturers to reduce the cost of manual labor, but also to search for economies in regard to the raw materials. The amount of platinum required in a lamp has been reduced to the smallest practical limits so that further economy in this direction can only be obtained by employing a cheap substitute. Of the numerous alloys that have been tried none has proven satisfactory. Platinum possesses several qualities which make it especially suitable for the purpose in question; not only is its coefficient of expansion the same as that of glass, but its chemical qualities appear greatly in its favor. M. Ch. Guillaume has shown that the physical properties of nickel-steel may be varied between wide limits by altering the ratio of its components, and the possibility of obtaining an alloy which possesses the same coefficient of expansion as glass; nevertheless the alloy is not suitable. Platinum is readily acted upon by silica and the chemical combination thus formed serves to keep the passage of the wires through the glass perfectly air tight. Nickel-steel does not possess this valuable property. A plastic compound has been used with success which serves the same purpose as platinum in keeping the glass bulb air-tight. This has a consistency similar to that of soft wax, and neither dries up under the influence of air nor melts under the action of the heat generated in the lamp. Its composition is however kept a secret by the manufacturers. In view of the increasing exhaustion of platinum mines, a solution of the problem is becoming pressing.

Automatic Pelton Water-Wheel Governor.—London *Engineering* contains an illustrated description of a new Pelton water-wheel governor, shown in the accompanying engravings, and devised by Watson, Laidlaw & Co., of Glasgow. The wheel casing, with the governor in position, is shown at the upper left hand, and a section through the jet nozzle is shown immediately to the left. The rod on core *A* is extended behind, and enlarged in diameter, to form the plunger *B*, which fits closely into a liner within the body of the nozzle. The helical spring inside the plunger exerts a constant pressure upon it, and tends to thrust the rod forward into the water jet, while at the same time the pressure of the water which enters at *D* tends to push the plunger back with greater force. The small holes *E* in the end of the plunger permit a certain quantity of water to pass into the chamber behind the plunger; and if the valve *F*, which communicates with the exhaust chamber *G*, be closed, the pressure behind the plunger will rise until it equals that in front, leaving the spring free to act without opposition. It is therefore apparent that the full closing of the valve *F* has the effect of reducing the water-gate to its minimum by allowing the spring to act freely; while the contrary effect will result from the full opening of the valve, owing to the effect of the water pressure on the plunger being greater than the power of the spring. Partial opening of the valve *F* will produce water-gates intermediate between the maximum and minimum, owing to the tapered form of the rod or core *A*. Full control of the wheel is therefore effected by the closing and opening of the valve *F* being made dependent upon the higher or lower speed at which the wheel runs. This result is attained through the operation of the governor, shown in the lower part of the engraving. The weights or pendulums *H* are attached elastically to the disc *J*, which is fixed to the wheel-spindle and revolves with it. They are held together by springs of suitable strength, to keep them in position till a speed above normal has been reached. Thereupon they fly out, engaging on their leather-covered surfaces with the inner rim of the loose pulley *K*, which they tend to pull round with them. The boss of this pulley has, however, a chain wound round it, attached to a spring, and the friction of the pendulums *H* has to overcome the tension of this spring before they can cause the loose pulley to turn. The loose pulley is prevented from revolving through more than one revolution by the pin *L*; but at all speeds materially over normal, the action of the pendulum will tend to draw the pulley over through an arc of a circle corresponding to the exact amount of the excess speed. It only remains to communicate this action to the spindle of the valve *F* in order to make the size of the water-jet dependent upon the speed of the wheel. This is done by leading the chain over a wheel on the spindle of the valve, as shown in the upper right-hand engraving. The governor is very sensitive, and can be adjusted to control the speed of the wheel within any required degree of variation of speed under great and sudden changes of load. It will be seen that this governor can be made to govern in two distinct ways. It can be so set as to govern the jet by regulating the flow of water proportionately to the load, or it can govern by opening the jet full, and closing it quite shut, so that the time during which water plays on the wheel is proportionate to the load. In either case the total amount of water discharged from the nozzle is proportionate to the work done.

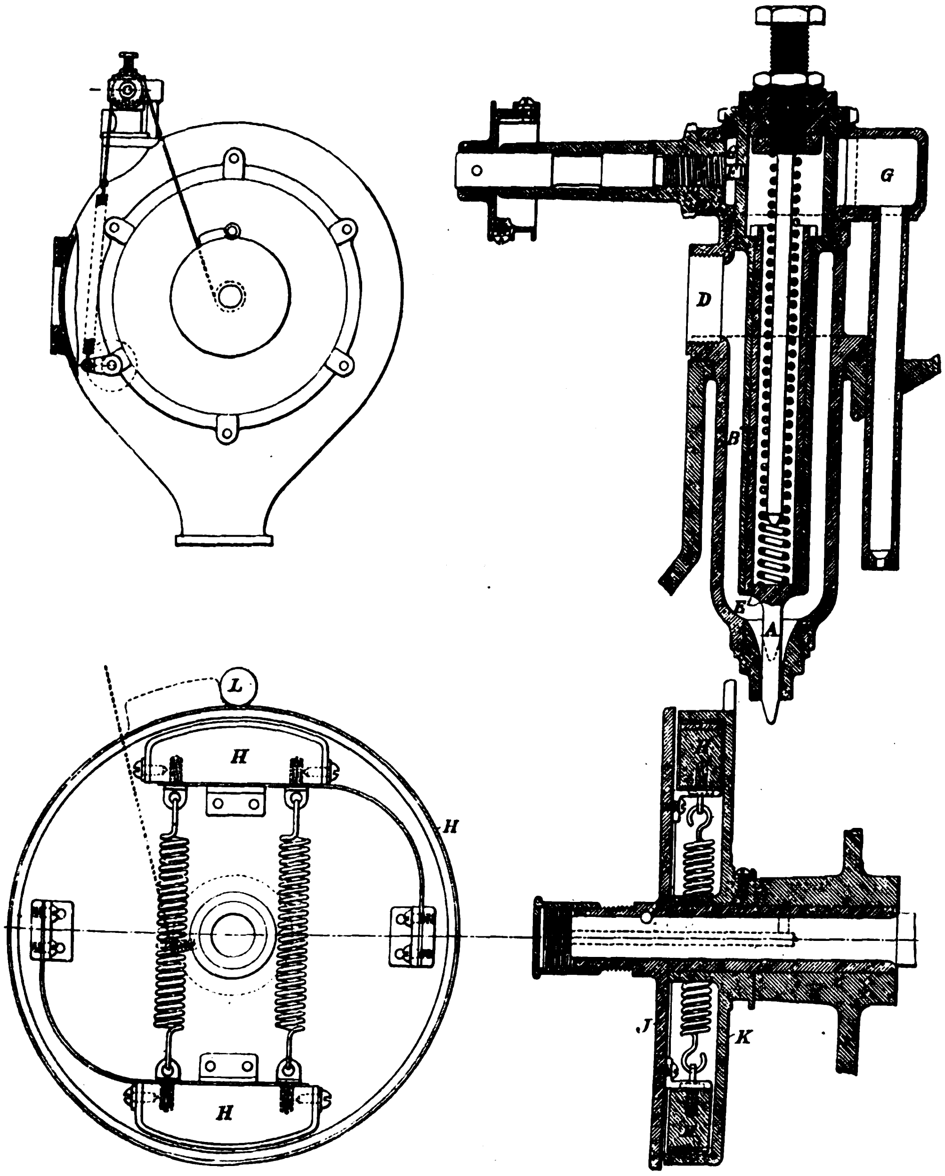


FIG. 4.—AUTOMATIC PELTON WATER-WHEEL GOVERNOR.

New Type of Transformer.—A recent issue of the *Elektrotechnische Zeitschrift* contains an article on a new type of transformer by E. Ziehl, in which the author describes a construction differing from the usual arrangement, which is to have the three cores of a three-phase transformer in one plane or at the angles of an equilateral triangle, with two yoke pieces in common to all three. As shown in the accompanying figure, the new arrangement consists in the superposition of two or more cores, each forming a closed magnetic circuit. The author states that this construction has the advantage of considerably simplifying the manufacture, inasmuch as for single, two and three-phase transformers equal cross-sections for the iron sheets, equal patterns for the magnet coils and equal armature parts, can be used. Comparing three individual transformers with a three-pole transformer of the new construction, the latter shows under otherwise equal conditions a considerably reduced weight of iron, inasmuch as the number of iron yoke pieces is only 6 instead of 8. With the same magnetization the losses are, therefore, diminished. Also, when the heat radiation of the new type is compared with that of the three-core type, it is found that the former has a considerably larger cooling surface, and a considerably greater capacity to dissipate the heat. The difference between the maximum inner and outer temperature of the iron will be about one-quarter of that in the old construction, which means that the maximum induction in the new type can be chosen higher. The case is similar with the coils, and another advantage in this connection is the division of the copper coils into as many parts as possible, thus getting a large cooling surface. From the possibility of a higher magnetism of the iron and a larger cooling surface, there results naturally the possibility of a higher current density in the copper, and, therefore saving in copper and iron. An influence of the magnetic fluxes upon each other cannot take place as the middle yoke pieces, between two phases, bring about an equalization of a one-sided load, because an excess of lines of force of one phase cannot enter into another phase-winding, but has to travel through the intervening yoke piece. The loss of potential from no load to full load, caused by the leakage and the ohmic

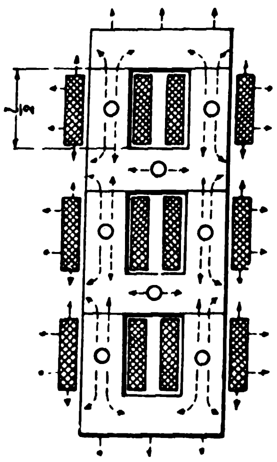


FIG. 5.—POLYPHASE TRANSFORMER.

loss, has with equal load on the phases, the same percentage value in each of them, because, apart from the ohmic loss, the lines of leakage or the leakage potentials, which appear on short circuit of the transformer, are equal in each phase. The leakage potentials themselves only reach very small amounts on account of the compact construction; that is, the smaller leakage surfaces and the longer leakage-line paths. Therefore, the total loss of potential of the transformer is very small. A transformer of 25 kilowatts capacity, running at 2200/210 volts and 50 cycles, had a total weight of 345 kilograms, including the oil, of which weight 59 kilograms were for copper and 116.5 kilograms for the iron sheets.

Method for Finding the Efficiency of Series Motors.—In a paper read before the British Association, Prof. E. Wilson gives the following method of finding the efficiency of series motors which has the advantage of great accuracy and works well in practice. Fig. 6 is a diagram of connections, in which *M* and *G* are two like machines mechanically coupled together, either through or without gearing, according as it is desired to obtain the efficiency of either machine inclusive or exclusive of gearing. In the test *M* runs as a motor and delivers its energy to *G* running as a generator. The field coils F_1F_2 are placed in series with one another, and with the motor armature in order that each machine may be conveniently magnetized to the same degree in any test. The input of the motor is measured on the voltmeter V_1 and ammeter A_1. The generator is loaded on a resistance, *R*, and its output measured on the voltmeter V_2 and the ammeter A_2. Let R_1 and R_2 be the ohmic resistances of the motor and generator armatures, respectively, then $V_1 A_1 - V_2 A_2 = X$ are the total watts dissipated in the system exclusive of the generator field coil F_2. Of these $A_1^2(F_1 + R_1) + A_2^2 R_2 = Y$ are the ohmic resistance losses in watts, and $X - Y$ are the watts due to brush, bearing and wind friction, eddy currents and magnetic hysteresis. The machines are equal and rotate at the same speed. $(X - Y) \div 2$ are the watts which can be debited to each machine when calculating efficiency, it being assumed that the brush contact resistance has the same value as when measured with the machines at rest, and that armature reaction does not produce inequality in the watts dissipated by eddy currents and magnetic hysteresis in the two machines. The expressions for the efficiencies are, for the motor, $[(X - Y) \div 2] + V_2 A_2 + A_2^2 R_2 \div V_1 A_1$, and, for the generator, $V_2 A_2 \div [(X - Y) \div 2] + A_2^2 R_2 + A_1^2 F_2 + V_2 A_2$. The above, so far, is a well-known method. The extension here described consists in the addition of two low-resistance shunts, $r_1 r_2$, a millivoltmeter, *a*, and a voltmeter, *v*. By these instruments the differences $A_1 - A_2$ and $V_1 - V_2$ have been measured as direct quantities. It is easy to show that greater accuracy can be obtained by measuring A_1 and *a* and using the value $A_1 - a$ instead of A_2, and measuring V_1 and *v* and using the value $V_1 - v$ instead of V_2. For instance, let $V_1 = 500$, $A_1 = 50$, $V_2 = 450$, $A_2 = 42$, $R_1 = R_2 = F_1 = F_2 =$ 0.5 ohm, and let there be a liability for error of 1 per cent in reading the instruments. Then the possible error in the value of $X - Y$, when $V_1 V_2 A_1 A_2$ are the measured quantities, is 31.9 per cent, whereas it is 1.9 per cent when $V_1 v A_1 a$ are the measured quantities.

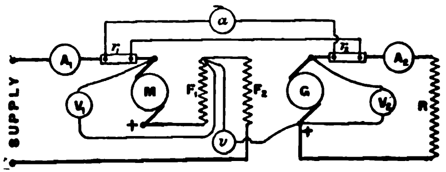


FIG. 6.—DIAGRAM OF CONNECTIONS.

New Secondary Cells.—The London *Electrical Review* describes some new types of storage cells devised by J. T. Niblett, which possess several novel features. Departing bodily from conventional lines, the builder has adopted the solid form of cell for stationary purposes, with a marked degree of success. The construction of the cell is shown by Fig. 8 herewith. The active material consists of pellets or small cylinders, about 5-16 in. in diameter, and the same length. These are made by compression in die plates, and when dry are exceeding hard; at the same time they are very porous, and will absorb a considerable amount of the electrolyte. The pellets are packed in a porous pot round the positive electrode, of the form shown in the engraving, while the space between the pot and the lead containing box (the negative electrode) is packed with disintegrated lead. A wooden case surrounds the whole. One of the advantages claimed for these cells is that, should the electrolyte escape by any means, it would not stop the discharge, as such a large quantity of the solution is absorbed in the pores of the active material and the separator, that it allows action to go on for some considerable time. Cells have been emptied and then discharged at the normal rate, and have given half their normal capacity under these conditions. Three distinct types of cell are made—the solid, which is more suitable for large central stations, etc., is considered the best since it has the advantage that short circuiting has practically no injurious effect. Owing to the enormous amount of exposed active material on both the positive and negative sides very high rates of charge and discharge may be taken from the cells without in any way injuring it. It is stated that even if excessive rates of discharge were taken from the elements, so as to cause slight expansion and disintegration, this would not be of harm, as the material would tend to settle at the bottom of the cell, and would in time solidify and become active so that no loss in capacity would occur. The second type is a semi-solid accumulator built up of special grids, which are thick and contain a large amount of active material. This is of the same composition as that contained in the solid cell, and being highly porous, may be used in thick masses. In this case ribbed porous plates are employed for the separators, and the elements are held together by stout clamping plates, which really constitute the outside negatives of the sets of elements. These clamping plates are pressed together by connecting bars having a flange at one end and a rubber pad pressing against this so as to allow for expansion and contraction during the charging and discharging operations. The third type of cell is of the portable variety used for ignition purposes, etc. They are of the semi-solid type and the elements are of a very robust character well calculated to withstand the jerking and jarring which they receive when on vehicles or when being carried about. The makers state that the cells behave much in the same way as the ordinary form of accumulator. The electrical pressure of the cells immediately after charging is about 2.2 volts, but this quickly sinks to 2 volts. On the discharge the fall of potential is proportional to the rate of discharge, but to discharge down to 1.7 volts for a lighting circuit is quite permissible, and in the case of railway and power circuits they may be discharged down to as low as 1 volt per cell. This apparently does not injure them in any way. As much as 95 per cent quantity efficiency and from 70 to 75 per cent energy efficiency has been obtained with both the solid and the semi-solid types of cell. The capacity per pound of complete cell, in the case of the solid batteries, is about four watt-hours. In the case of the smaller cells it may be somewhat less, but as the capacity per pound of the cell increases, the capacity per pound of complete cell tends to increase, a condition not usually met with. In the case of

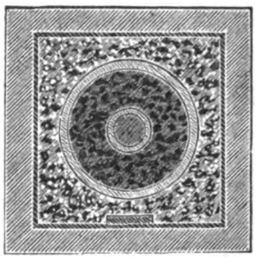


FIG. 7.—NIBLETT STORAGE BATTERY.

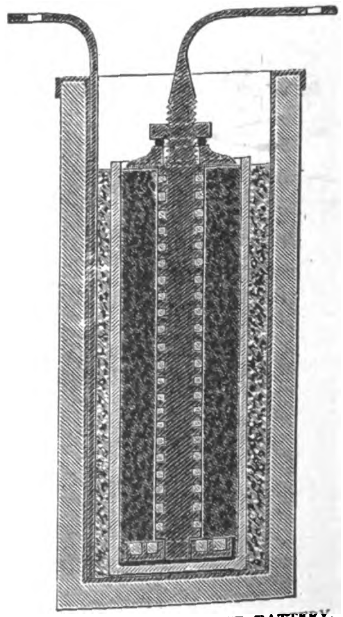


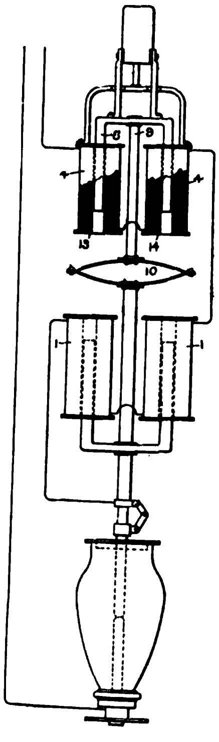
FIG. 8.—NIBLETT STORAGE BATTERY.

the semi-solid cells, about 10 watt-hours per pound of complete cell are obtained, but this, of course, is regulated by the nature of the containing boxes, whether they are of vulcanite, glass or lead-lined wood. With the small portable batteries, capacities have been obtained up to 12 watt-hours per pound of complete cell. A solid cell made up some 15 months ago was taken out of a battery, discharged, and then emptied, and was allowed to stand idle for a space of four months. At the expiration of this time the cell was filled up with electrolyte, and put on charge, and after one or two charges and discharges it was found to be in perfect condition. The cells have been frequently short-circuited, but no detrimental effect seems to occur; they have also been run down until they showed absolutely no pressure whatever, and on the re-charge they appeared to come up quite well. This is believed to be due to the fact that the elements have an enormous amount of exposed surface, and the active material cannot disintegrate or leave the conductor. The simple construction of the "solid" cell, rendering skilled labor superfluous, is one of its most prominent features.

Wind-Driven Generators.—For more than two years two small factories, one near Leipsic, the other near Hamburg, have been satisfactorily driven by windmills, which are also used as a means of generating electricity for lighting purposes. *The Elektrotechnischer Anzeiger* states that the windmills have a diameter of five metres and five and one-half metres, respectively, and are mounted on the roof of the works. To ensure reliability the wind-wheel itself has no moving parts, the speed regulation being obtained by turning the windmill so as to vary the angle under which the wind impinges upon the vanes, which are built of steel sheets. This is performed by a small auxiliary wind motor, and is said to be done so quickly and accurately that the voltage of the dynamo remains practically constant throughout the range of ordinary wind pressures. An automatic switch cuts out the battery connected in parallel with the dynamo as soon as the wind falls below a certain point. In one of the cases mentioned the battery was divided into two parallel groups so as to utilize unusually low winds.

SOME RECENT ELECTRICAL PATENTS

Arc Lamp.—With a view to obtaining steady operation in an arc lamp without the use of a steadying resistance in series with the lamp, or with a resistance much lower than that usually necessary, W. C. Fish has devised and patented the idea of providing two regulating magnets connected in series, one of which is adapted to respond quickly to variations in the current while the responsiveness of the other is greatly retarded. Such an arrangement is shown in Fig. 1 herewith, where 1 indicates the main regulating magnet, and 4 the retarded compensating magnet. These two, as the engraving clearly shows, work in opposition to each other, the main magnet being arranged to lift the carbon and the compensating magnet, 4, opposing this action. The two sections of the carbon feed rod, 6 and 9, are connected together flexibly by means of bow springs, 10. The action is as follows: When at rest the carbons are together, and when current is passed through the lamp the main magnet, 1, is excited immediately and strikes the arc. The compensating magnet, 4, lags in its magnetization by reason of closed secondary circuits, 13 and 14, consisting of solid copper tubes within the exciting winding. After a minute interval of time, however, the compensating magnet becomes fully excited and opposes the main magnet, thus restricting the length of the arc drawn by the latter, and preventing an excessive fluctuation of current through the windings. In the case of a momentary decrease of current, the main coil, 1, responds instantly, and tends to drop the carbon. The compensating magnet does not respond promptly, and therefore assists in the downward pull and quickens the action of the mechanism. The springs, 10, still further assist in making the carbon responsive to variations of the current in an obvious manner. In short, the operation of the two magnets is to make the carbon rod instantaneously responsive to fluctuations in the current and at the same time check it from over-travel, which would, of course, produce hunting or pumping. Fig. 2 illustrates an elaboration of the method just described, which consists of connecting the compensating magnet in series with an inductance coil, 24, and shunting the two with a non-inductive resistance, 25, which permits current variations to affect the main magnet instantly, and still further retard the responsiveness of the compensating magnet. Patent No. 738,896.



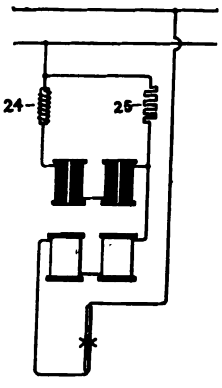
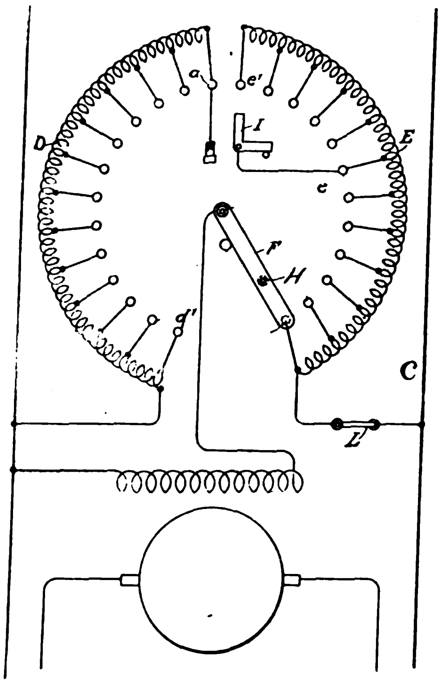


FIG. 1.—FISH ARC LAMP.—FIG. 2.

Dynamo Field Rheostats.—Fig. 3 herewith illustrates diagrammatically an ingenious rheostat construction which has been patented by Leonard Wilson, and which combines two advantages as compared with the ordinary style of rheostat; one is that the excitation of the field winding to which the rheostat is applied may be varied from zero to maximum by the use of a quantity of resistance material much less than would be required for an ordinary series rheostat; the other advantage is that the field winding may be disconnected from the exciting circuit without entailing an inductive discharge or "kick." The resistance conductor is divided into two groups, *D* and *E*, connected up as clearly shown by the diagram. The rheostat arm, *F*, is shown in the position for maximum field strength.



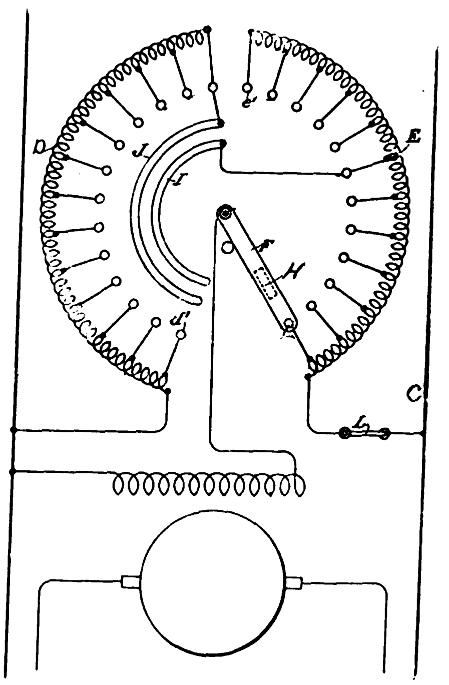


FIG. 3.—WILSON DYNAMO FIELD RHEOSTATS.—FIG. 4.

In order to weaken the field the arm is moved counter-clockwise, cutting in the successive sections of the resistance conductor, *E,* in the ordinary manner until the arm reaches the button, *e'*. When it is moved from this button over to the button, *a,* a stud, *H,* on the rheostat arm closes a small auxiliary switch, *I,* which connects the button, *a,* to the button, *e,* thereby putting the resistance, *D,* in series with that portion of the resistance, *E,* which is connected between the button, *e,* and the line wire, *C.* When the arm, *F,* rests on the button, *a,* the resistance, *D,* is obviously in parallel with the field winding, the two being in series with the lower part of the resistance, *E.* As the arm is moved further around counter-clockwise, the resistance in parallel with the field winding is gradually decreased, and when the arm rests on the button, *d',* the field winding is obviously short-circuited and the switch, *L,* may be opened without producing any kick. Fig. 4 indicates another method of obtaining the same result; in this case a brush, *H,* on the rheostat arm travels around segments *I* and *J* after the arm reaches the button, *a,* the result being the same as when the switch, *I,* in Fig. 3 is closed. The object of connecting the resistance, *D,* in series with only part of the resistance, *E,* instead of with the whole resistance, is to prevent too great a change in the excitation of the field winding when the arm, *F,* moves from the button. *e',* to the button, *a.* Patent No. 741,207.

Brush-Holder.—Figs. 5, 6 and 7 herewith illustrate a compact form of brush-holder patented by Charles A. Eck. The brush, 4, is pressed toward the commutator by the compression spring, 15, mounted in a tubular casing and pressing against a plunger, 8, to which plunger is attached a horizontal pin, 9, carrying at its outer end a pivoted piece, 11, which is formed with two fingers, 12 and 13, adapted to engage the rear end and outer side or edge of the brush. It will be obvious from an inspection of Fig. 6 that the pressure imparted to the pin, 9, by the spring, 15, is transmitted to the rear end of the carbon by the finger, 12, while the lever action between the finger, 12, and the finger, 13, causes the latter to press the brush also against the flat face of the brush-holder. The brush is, therefore, pressed against the commutator and also held firmly against the brush-holder by the single spring. Fig. 5 is an elevation of the holder and Fig. 7 is a plan view showing the method of removing the brush from the holder. As shown by Fig. 5, it travels between two ledges or flanges, 7, so that it would not be easy to get hold of the brush with one's fingers. By throwing the double-fingered lever, 11, around, as shown in Fig. 7, and pressing the commutator end of the brush away from the holder by means of a thin piece of metal, such as a screwdriver blade, inserted between the commutator and the holder, the brush may be readily thrown out from between the jaws or flanges, 7, in a direction parallel with the armature shaft. Patent No. 740,635.

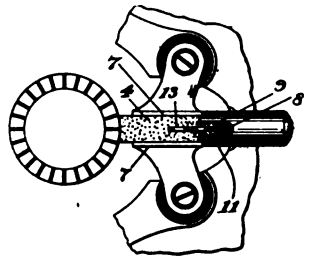


FIG. 5.—ECK BRUSH HOLDER.

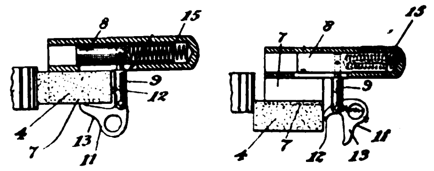


FIG. 6.—ECK BRUSH HOLDER DETAILS.—FIG. 7.

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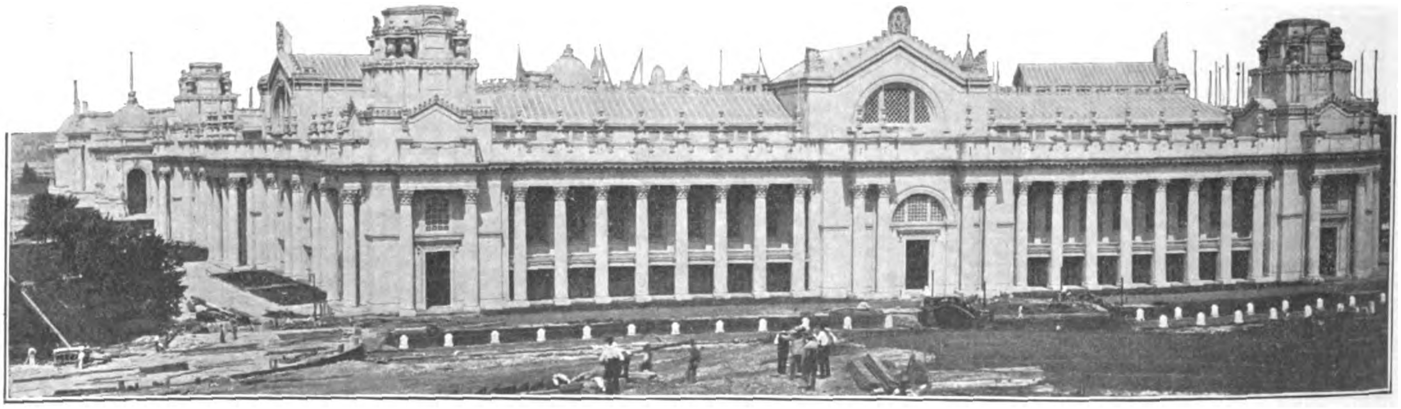
ELECTRICAL EXHIBITS AT THE ST. LOUIS EXPOSITION.

The Electricity Building promises to be one of the chief attractions at the St. Louis Exposition next year, on account of the large number and variety of operating exhibits. The building itself will be highly attractive on account of its beautiful appearance, as may be partially realized from an inspection of the accompanying engraving, which shows western facades of the Palace of Electricity.



SOUTH FACADE OF ELECTRICITY BUILDING FROM THE CASCADES.

The largest group of electrical exhibits, both as to area of space and number of exhibits, will be that of machines for generating and using electricity. Dynamos and motors of all the principal makes, both alternating and direct current, will be on exhibition. There will be shown many ingenious applications of motors to the diverse forms of power machines, in which so much progress has been made in recent years, and opportunity will be given for both still and "live" exhibits of street railway apparatus. That within the Electricity Building will consist chiefly of motors, controllers, switchboards and auxiliary apparatus. Outside there will be a double-track testing road about 1400 feet long, upon which speed, acceleration, braking and efficiency tests can be run. Electric railway equipments of standard form will be tested, and not only this but systems now being developed will be given an official trial. Signal apparatus and safety devices of every form will have opportunity to demonstrate their utility.

Arrangements have been made for showing the phenomena of high potential currents beyond anything in this line attempted in previous expositions. While proper safeguards will be thrown about such demonstrations, yet it is intended to make them in such a way that the general public as well as electrical engineers may profit by them.

Perhaps the wireless telegraph and telephone exhibits will attract as much attention as any other feature on the grounds. The largest wireless telegraph station ever erected will have a conspicuous location where visitors may send messages to St. Louis and adjoining cities. Several inventors and companies have prepared plans for exhibits of wireless telephony over comparatively short distances; telephone stations at the ends of the building will be installed for this purpose.

The inventions in electric lighting which have been made in recent years will all be demonstrated. Arc and incandescent lamps of every kind will be shown, of course, and Nernst lamps will be utilized in lighting one of the buildings. Cooper-Hewitt vapor lamps will illuminate the cascades and will be shown inside of the Electricity Building.

Arrangements have been completed for the establishment of special laboratories with complete sets of recording instruments whereby the juries of award and exhibitors may conduct accurate tests upon every kind of electrical apparatus which may be shown in the Electricity Building. The presence of such laboratories at an Exposition is a new departure, and will add greatly to the value of the awards, as the personal factor and the personal judgment of the jury will be minimized because the actual data regarding performances of the machines or mechanism can be accurately ascertained.

NOTES.

Electrical Workers' Convention.—At the convention of the International Brotherhood of Electrical Workers, held recently in Salt Lake City, F. J. McNulty, of Newark, N. J., was elected grand president; W. S. Sherman, of Washington, grand secretary; F. J. Sheehan, New Britain, Conn., grand treasurer. The next convention will be held in El Paso, Texas.

Kansas University.—The members of the faculty of the Kansas University, students and others interested in the University recently passed resolutions to ask the State Legislature to appropriate a sum sufficient to erect a new engineering building and install better equipment in the University. The attendance has increased nearly 75 per cent, and the old buildings and equipment are not sufficient to accommodate the students.

The Brooklyn Engineers Club held the first meeting of the season on the evening of October 8. Besides the usual formal business, a very interesting paper entitled "A History of Pumps, Ancient and Modern," was read by Mr. John A. Drew, of the Worthington Company. Mr. Drew sketched the development of pumping machines from the early Egyptian "noria," resembling the familiar well-sweep, to the latest triple-expansion, condensing, water-works pumping engines, requiring little more than a pound of coal per horse-power-hour. The paper was illustrated by lantern slides.

The Ohio Electric Light Association held its ninth annual convention at Columbus, Ohio, October 13 to 15, inclusive. Several interesting papers were read, including one on "Boilers and Boiler-Room Equipment," by W. D. Chester, of the Babcock & Wilcox Company; one on "Engine Economy and Equipment," by E. J. Bechtel, of the Toledo Railways Company, and another on "The Combined Use of Direct and Alternating Currents for Central Stations," by Prof. F. C. Caldwell, of the Ohio State University. Charles Mosman, of the General Electric Company, also presented some interesting notes on "Certain Three-wire Systems."

Fire in the Snoqualmie Falls Plant.—A fire which burned down the transformer house of the Snoqualmie Falls Power Company at Snoqualmie Falls, Wash., six weeks ago, will go down in history among the notable accidents to large transmission plants. The fire destroyed the entire transformer house of this company, which operates long distance transmission circuits at 33,000 volts to Seattle and Tacoma and intermediate points. Mr. Charles H. Baker, president of the company, states that the origin of the fire is unknown, although there is some reason to think that it was incendiary. The fire started in one of the transformers, and the burning oil escaping in every direction set fire to the neighboring transformers, and finally to the building itself. Ten out of the thirteen transformers were destroyed, and the roof of the building was burned out. About two-thirds of the service was soon restored by sending step-down transformers from Seattle and Tacoma and using them as step-up transformers. The fire is not without its lessons in an engineering way, and the transformer houses of the future will probably be built with more thought than has heretofore been given to the possible escape of burning oil and communication of fire in other transformers. The company's loss by this fire is estimated at about $40,000.

Electrical Developments at Duluth.—The leading mining and transportation officers of the United States Steel Corporation, accompanied by electrical engineers from the Westinghouse and General Electric Companies and of the Great Northern Power Company, of Duluth, Minn., have been on the Mesaba Range within the past month, investigating the problem of iron ore transportation. Both electrical companies are making estimates as to the cost of equipping and operating the Duluth & Iron Range and Duluth, Mesaba & Northern ore railroads electrically. It is proposed to secure power from the water of the Great Northern Power Company, and according to report the projectors will use 1800-h.p. single-phase(?) locomotives and discard steam locomotives between main line terminals. The two roads haul up to 2,000,000 tons of ore a month for an average distance of 75 miles. The General Electric Company, it is reported, has made figures for converting the entire main ore line of the Great Northern road from the Mesaba Range terminals to Duluth from steam to electric locomotives, basing the bids on the generation of electricity by means of a central steam turbine plant, and also on the use of the water of the power company to drive hydraulic units.

Fire in Seattle Storage Battery Plant.—A fire, which occurred in the battery room of the Post Street Station of the Seattle Electric Company recently, is interesting as showing the manner in which the storage battery survived it. The battery was a 500-volt railway battery of the Chloride type. The battery room was not a part of the original station, but was added after the construction of the main building had been completed. It was on the top floor and had brick walls, with wooden columns and roof supports, and a tar and gravel roof. The fire destroyed the roof and charred the outside of forty-eight tanks. It melted the top crowning of lead off the tanks, so that it is not considered advisable to use them again permanently, although they have been put in temporary service; it also melted off the lugs of about 1000 plates. The acid was spoiled by firemen getting chemicals from their chemical engines and dirt into the tanks. Many of the glass rods were broken, but more were broken by the firemen dragging hose across the tanks than by the heat. None of the plates were injured. New lugs were soldered on to replace those which were lost, and the battery was put in operation again in a few days, using the damaged tanks. The tanks will be replaced by new ones as soon as possible, although the old ones did not leak. The electrolyte was renewed throughout. Aside from the effect on the battery, the fire served to emphasize the danger that may lurk in telephone circuits. Officers of the company were inclined to think that the fire was started by the burning out of a telephone in the battery room. This telephone is on a circuit which is run on the same poles with a 25,000-volt transmission line.

The Marienfelde-Zossen High-Speed Trials.—These interesting high-speed electric traction trials have at last given the anticipated results; the highest authorized speed of 200 kilometers (125 miles) an hour was reached and even slightly exceeded on October 6, and a speed of 130.4 miles was attained on October 23. These events aroused great interest, and the performances were witnessed by a large number of lookers-on. As might have been anticipated from the previous trial when speeds as high as 189 kilometers were attained, the Siemens electric equipment of the car has shown excellent performance in this remarkable run, in spite of the enormous strain involved by the acceleration up to the required speed over so short a track. On October 6, the line, 23 kilometers (14.3 miles) in length was repeatedly traversed in not more than 8 minutes, including starting and braking, the maximum speed of 125 miles an hour being reached on the Mahlow-Rangsdorf section, about 3.1 miles long, which was traversed in 1½ minutes. At the average speed of 175 kilometers per hour shown in this test, the journey between Berlin and Cologne (577 kilometers) could be made in about 3¼ hours, whereas the fastest present trains require fully 9 hours.

Oscillations of the poles and wire resulting in some fractures and short-circuits, as were formerly observed, have been obviated by means of lighter contact "bows," fitted with better springs, as well as by some minor improvements in the conductors. The track has been wholly renewed, the gravel bed being replaced by a bed of finely pounded basalt; safety rails were used as safeguards against derailments. The sleepers used are those generally employed with Prussian railways in connection with fast trains. In spite of the enormous speed, no disturbing results were observed during the run, the cars running so smoothly that passengers were able to make writing records both in sitting and standing positions. It may be mentioned that the air pressure produced by the carriages was about 200 kilograms per square centimeter (2845 pounds per square inch), *i. e.*, nearly 200 times greater than the ordinary pressure.

Further trials are to be made with the car supplied by the Allgemeine Elektricitäts-Gesellschaft; moderate speeds (ranging up to 100 or 150 kilometers) will be used at the beginning, until the working conditions of the new car are ascertained.

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CONTENTS.

Power Plant of the Bronx Gas and Electric Company at Westchester, N. Y. ... 529
Asynchronous Generators, by A. S. McAllister ... 534
Fly-wheels and Fly-wheel Accidents, by R. T. Strohm ... 536
An Interesting Turbine Installation ... 539
Telephone Engineering, by F. J. Dommerque 542
Electric Motors for Centrifugal Pumps and Fans, by A. J. Bowie, Jr. ... 544
Abstracts from Foreign Contemporaries ... 546
Some Recent Electrical Patents ... 549
Electrical Exhibits at the St. Louis Exposition 550
Notes ... 551
Editorial ... 552
Construction of a Small Variable Voltage Transformer, by W. B. Roberts ... 554
Some Notes on the Hunting of Rotary Converters, by Clarence P. Fowler ... 556
Boiler Settings, by C. L. Hubbard ... 557
A Common Battery Private Branch Exchange, by A. D. O'Brien ... 560
Erecting Telegraph Lines Under Difficulties . 562
Lessons in Practical Electricity ... 563
Letters on Practical Subjects ... 565
Queries and Answers ... 568
Burger Automatic Gas Engine ... 569
The Warren Rotary Engine ... 570
New Apparatus and Appliances ... 571
New Foundry and Pattern Departments of the Sturtevant Company ... 573
New Books ... 574
Obituary ... 574
Personals ... Adv. 55
Trade Publications ... Adv. 55
Business News ... Adv. 55

Centrifugal Force in Fly-wheels and Armatures.

Although it is possible that none of our readers may ever have occasion to build or design a fly-wheel, the article on fly-wheels which appears on another page should be of interest and value to all who are concerned with the operation of engines. It is highly probable that the fundamental formulas for stored energy and centrifugal force, on which the article is necessarily based, are familiar to most if not all operating engineers, but the author's treatment of the subject is by no means the familiar hackneyed one.

As stated in the article referred to above, the usual limit of velocity for cast-iron fly-wheel rims is about 6000 feet a minute, which allows an apparently excessive factor of safety. Practice has demonstrated, however, that while this figure has been greatly exceeded in some cases, some disastrous accidents have occurred at even lower velocities, so that the stated limit is a good one to observe. In designing fly-wheels of moderate size a few years ago the present writer found it very satisfactory in simple cases to adopt the relation 22,000 ÷ r.p.m. = mean diameter (d) of the rim, in inches, for solid wheels, and 18,000 ÷ r.p.m. = d, for split wheels. These give, of course, a mean velocity of 5760 feet per minute for solid wheels and 4712 feet for split wheels. On this basis, the relation between the energy (e) stored in the rim and the section (s) of the rim in square inches becomes, for cast-iron, $e \div 1200\, d = s$ in the first case and $e \div 800\ d = s$ for the second. These four formulas combined the advantages of simplicity in computation and safety in results within the limits of the work to which they were applied.

The design of dynamo and motor armatures also involves a consideration of centrifugal force, of course, although in machines of moderate size there is no need to consider tensional stresses in the material of either the core or the windings. The only effect to be guarded against in such cases is the tendency to throw the coils out of the slots. With peripheral velocities under 4000 feet a minute, no computation is necessary in order to determine the restraining force required to hold the conductors in the slots, for the reason that the thinnest wedges that are strong enough to stand being driven in the slots, above the conductors, are sufficiently strong to hold the latter in place; if binding wires are used, three ¾-in. bindings on a barrel-wound armature or two on a headed armature will hold any winding in place at or below the velocity named, provided the relation between diameter and length of the armature core is normal according to modern methods of design. In a toothed armature the effective weight of the conductors, as regards the tendency to fly out of the slots, may safely be put at one-fourth of the total weight of the winding. If a net tensile stress of 18,000 lbs. per sq. in. be assumed as safe for the binding wires, ignoring the restraining effect of friction in the slots, and the total weight of the winding be represented by w, the aggregate cross-section of binding wires required may be ascertained from the formula: $s = d\, w\ (r.p.m.)^2\ 10^{-10}$ from which it will be apparent that the calculation of binding wires does not enter in the great mass of ordinary cases.

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The Motor-Generator vs. the Rotary Converter.

It appears somewhat peculiar that so little appreciation of the motor-generator as a means of translating alternating currents of moderately high voltage into direct current of relatively low potential has been manifested in this country. This type of converting apparatus is extensively employed in Europe; indeed, it appears to be given the preference there over the single machine. The type chiefly used consists of an induction motor and a direct-current dynamo with shafts rigidly coupled, and it goes without saying that the commercial efficiency of this combination is lower than that of a rotary converter and its transformers. The power factor is also lower and the angle of phase difference between the impressed alternating e.m.f. and the current taken from the line is invariably negative, whereas it is possible to obtain leading currents with a converter. Since the differences in efficiency, power factor and phase sign between a motor-generator and converter are not commercially of great importance, however, these qualities would appear to be collectively subordinate to those of flexibility and peaceable operation, which are inherently characteristic of the motor-generator and conspicuously absent in a converter. Notwithstanding the splendid work of those engineers responsible for the development of the rotary converter to a workable machine, it remains, and must always be, a mongrel sort of production possessing very few of the good qualities and all of the bad ones of each class of which it is a compromise combination, together with some idiosyncrasies peculiarly its own.

The chief drawback of the class of motor-generator here discussed is the lower power factor of the motor, assuming this to be of the asynchronous or "induction" type. And this drawback is enhanced by the conditions under which such an outfit is most frequently operated—with widely varying loads. Just here would seem to come in strongly the merit of the Heyland "compensating" construction, by means of which the asynchronous motor may be made to behave somewhat like a synchronous machine, as regards the character of its power factor. But even with the simple induction motor the showing is not bad. Recent tests of a 250-kw. European set showed a power factor of 92 per cent at half load and 95 per cent at full load, and over-all efficiencies of 88 per cent at half load and 90 per cent of full load. We should keenly enjoy following through a complete comparative test of a rotary converter and a motor-generator in which the compensated induction motor was employed, the test being made under commercial rather than laboratory conditions.

◆

Electromagnet Construction.

A rather interesting, if somewhat "freakish", departure in the construction of electromagnets is described briefly in our department of Abstracts from Foreign Contemporaries this month. The method is a modification of the ancient multitubular magnet of Camacho, the core of which consisted of nested concentric tubes instead of a solid rod. In the present arrangement each leg of the magnet is a group of parallel strips—in short, a number of relatively thick laminations, if the bull may be allowed, widely separated. The winding, instead of enclosing the whole group of strips, as it rationally should, starts in the center, encircles one strip, then two, then three, and so on, each successive section of the winding enclosing more and more core strips; the winding per phase per pole of an inductor motor stator is very similar in character, so far as the arrangement of the winding in the slots is concerned—indeed, one might be justified in supposing that the present construction had been "inspired" by contemplation of such a stator winding. But there is this vital difference between the stator winding and the De Mare magnet winding: the former sets up a flux in teeth *not* intermeshed with the winding and which are, therefore, not subjected to magnetic stresses opposing each other, whereas the iron path for the flux in the De Mare magnet is through teeth which are subjected to magnetic stresses of opposite tendencies. The saving facts are that these opposing stresses are unequal, the distribution of the winding is unsymmetrical, and the central tooth or strip is magnetized in the ordinary fashion.

It has long been known that the division of a magnet core into a number of parallel bars would enhance the effect of the magnet upon an armature. This is due to a more nearly uniform distribution of flux in the core, and the improvement in results is obtained without interweaving the winding. As a matter of fact, the arrangement of windings applied to the De Mare magnet mentioned above is obviously less effective than if all of the convolutions enclosed all of the strips of each leg. Where large magnets are used for tractive purposes it has been found advisable to group a considerable number of small individually-wound cores as closely as their windings will permit, adjacent pole ends or faces being of opposite sign throughout the group, and the whole group being set into or attached to a single yoke plate.* This arrangement has the advantages that the flux distribution in the cores is much nearer uniformity than it would be with a single pair of large cores, and the magnetic circuits are shorter, the distance between the centers of adjacent poles being much less than with two large cores. The slotting or dividing up of the magnet cores as suggested by M. de Mare merely accomplishes the former result, the slots being transverse to the direction of the magnetic path through the yoke and armature, and thus tending to prevent the crowding of flux toward the inner edges of the circuit. With a conventional winding the magnet would doubtless show much greater strength than it does with the embedded winding, under correct conditions as to exciting force and armature fitting.

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The Jerry Wireman.

Like "the poor," the jerry wireman we shall "always have with" us, and it were a waste of time and mental effort to hope otherwise. But certainly some means should be devised whereby his pernicious activity may be restrained more effectively than it now is. The inspection system of the National Board of Fire Underwriters, rigid as it is in intent, is inadequate in this respect; in fact, it is extremely doubtful if any system of inspection of completed work, however well applied, can prevent the jerry wireman from getting in his villainous slopwork. Joints consisting of three turns of one wire around the straight end of another wire and anointed with a perfunctory dab of solder do not show up under inspection as ordinarily performed, and there are many other defects, of varying importance, that cannot be detected by the external inspection of a completed job. Continuous inspection during the progress of the work is the only way by which thorough work can be absolutely assured, but the impracticability of this is obvious. We confess our inability to suggest any other efficacious means of preventing poor work, but the need of it is becoming daily more and more imperative.

◆

Voltage Ratio of Induction Coils.

Evidently recognizing the similarity between the ordinary induction coil and the now familiar transformer, many readers have made request during the past few months for a practical method of predetermining the secondary e.m.f. of an induction coil on the basis of the data relating to the primary winding and the ratio of secondary to primary turns of wire. Of course the desired information has not been forthcoming for the very good reason that there is no practical method of predetermining the ratio of secondary to primary e.m.f., nor even any academic method that is worth one-tenth of one per cent of the time expenditure that its application would require. Even if it were practical to predetermine the effective magnitude of the pulsating magnetic flux that the interrupted primary current would set up, the effective secondary e.m.f. could not be approximated reliably because of the impossibility of calculating the flux distribution as regards secondary linkage and the leakage in the secondary winding due to inadequate insulation. In short, there is no definite ratio between the impressed primary e.m.f. and the terminal secondary e.m.f. of an induction coil as commercially constructed.

While the principle of the transformer is precisely the same as that of the induction coil, the construction is such as to eliminate all of the uncertainties which defeat any effort to calculate the secondary to primary ratio of an induction coil. The primary current rises and falls at the same rate, whereas the primary current of an induction coil falls much more rapidly than it builds up, and the suddenness with which it does fall varies widely with different forms of interrupter and different adjustments of any given form, and the downward curve cannot be predetermined. Worse still, the magnetic circuit of an induction coil is part iron and part air, and the reluctance of the air part and the magnetic leakage past parts of the secondary winding cannot be computed with any degree of accuracy; on the contrary, the transformer has a closed magnetic circuit through iron, so that the reluctance of the circuit can be accurately foretold, and the windings are so intermeshed that the leakage is reduced to an insignificant proportion, easily computed.

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* Page 65, AMERICAN ELECTRICIAN, Feb., 1901.

CONSTRUCTION OF A SMALL VARIABLE VOLTAGE TRANSFORMER.

BY W. B. ROBERTS.

The accompanying sketches illustrate a design for a small transformer having a maximum capacity of about 80 watts and capable of furnishing a secondary pressure that can be varied from zero to about 5 volts. Some time ago the writer had occasion to design a small transformer for heating physicians' cautery knives. A transformer for this purpose was at hand, but it was found to be incapable of heating the heavier knives and maintaining them at the proper temperature when in use. The transformer referred to consisted of a straight laminated core with the primary wound thereon, and with the secondary wound on a spool arranged to slide over the primary. This transformer would heat the smaller knives satisfactorily, but when called on to furnish a large current, its voltage dropped so much that the current could not be maintained. This type of transformer requires a large magnetizing current and the magnetic leakage is excessive. On the other hand it has the advantage of giving a very convenient means of varying the voltage by very small amounts, the variations being much more gradual than is possible with a secondary winding divided into sections and connected to a multi-point switch. For work such as heating cautery knives or for other purposes when the heating effect of the current is utilized and where the voltage at its highest value is not very great, it is important to be able to vary the voltage by very small increments, and this cannot be done with a sectional winding unless a very large number of taps are brought out, thus making the transformer difficult to construct.

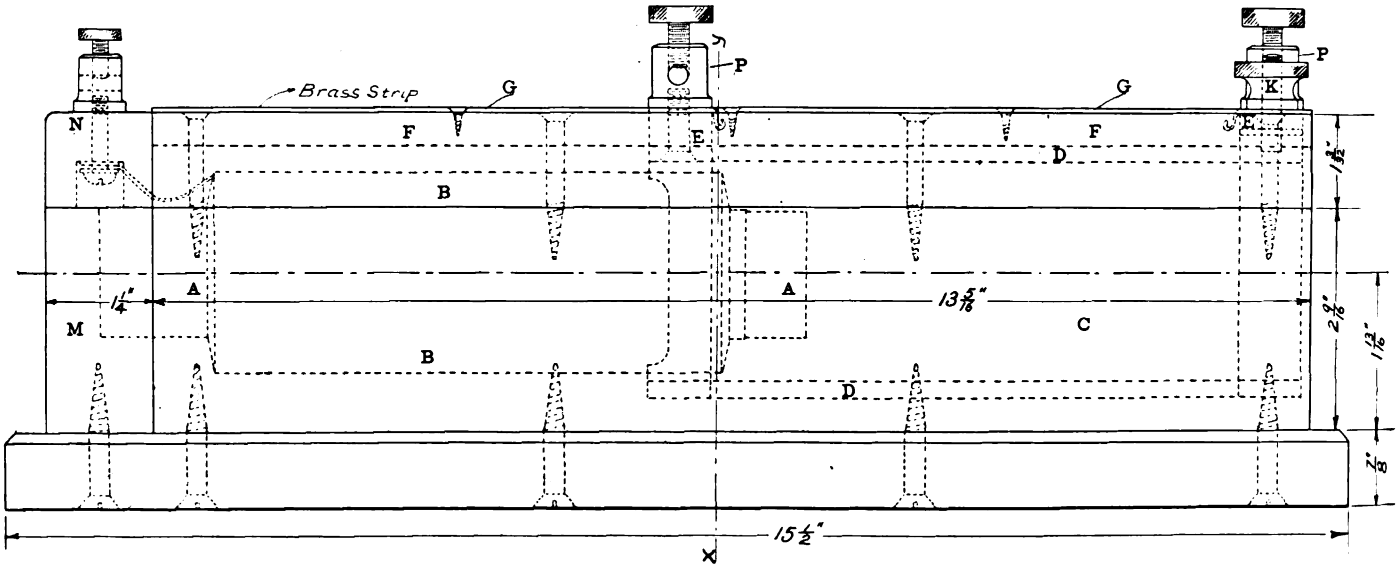

FIG. 1.—SIDE ELEVATION OF VARIABLE-VOLTAGE TRANSFORMER.

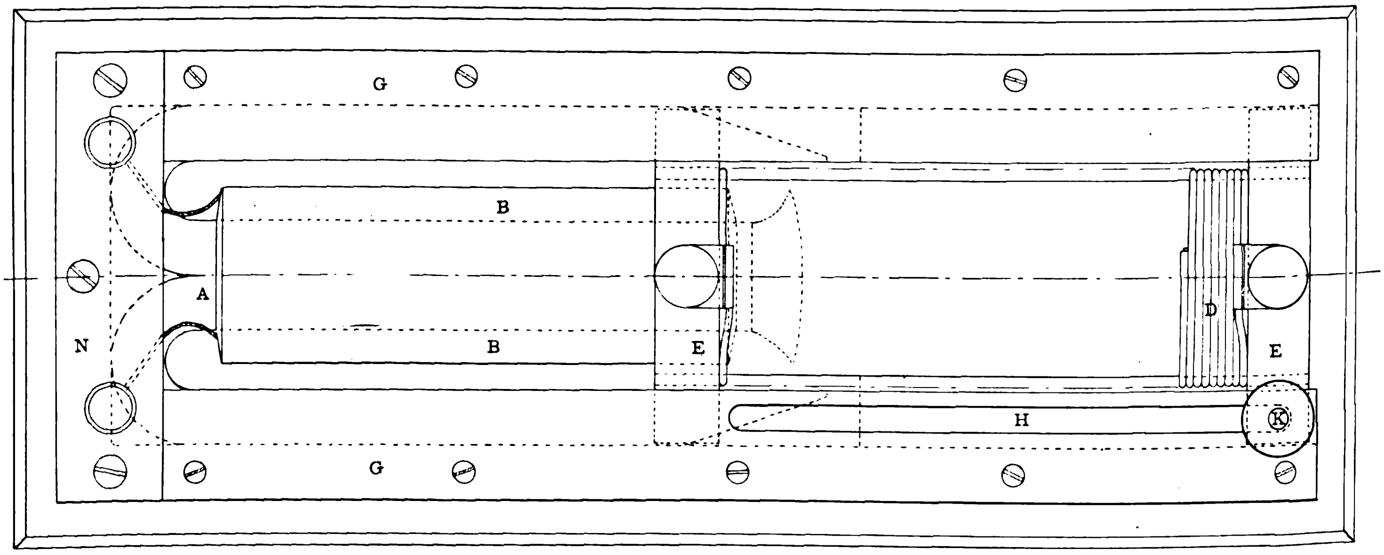

FIG. 2.—PLAN VIEW OF VARIABLE-VOLTAGE TRANSFORMER.

In designing the transformer illustrated herewith the object was to combine, as far as possible, the advantages of the closed magnetic circuit transformer with its comparatively small magnetizing current and magnetic leakage, with those of the straight core transformer having a movable secondary and consequent gradual variation in secondary voltage. While the transformer was designed primarily for the heating of cautery knives it has proved very useful for any experimental work requiring an adjustable alternating voltage within its range. It can also be used as a voltage regulator, as described later. It is capable of heating any of the cautery knives in common use; in fact, it has a larger output than is really needed for this work. In designing the transformer the chief aims were to make the magnetic circuit as nearly closed as possible, to make the resistance of the coils low, to make the clearance between primary and secondary as small as practicable in order to reduce magnetic leakage, and finally to make the construction simple throughout.

Figs. 1, 2 and 3 are general views of the transformer, Fig. 3 being a sectional view on the line x-y, Fig. 1. In these figures, *A* is the laminated core built up of iron strips as described later; *B* is the primary coil wound over the core. The core, with the primary coil, is held by the hardwood pieces *C, C,* which have suitable grooves in which the core is fastened; *D* is the secondary coil wound on a suitable framework and hung from the sliding cross-pieces, *E, E,* which slide in grooves in the strips *F, F.* Brass pieces, *G, G,* keep the sliding coil in place, and one of these is slotted, as shown at *H*, to receive the stud, *K*, which is threaded to receive the clamping screw *L*. It is necessary to provide means for clamping the secondary in any desired relation with regard to the primary because, when current flows in the coils, there is a marked repulsive action between the two, and the secondary will slide off if it is not clamped securely. The core is supported at the back end by hardwood pieces, *M* and *N*, one of which carries the primary binding posts as shown. The secondary binding posts, *P, P*, are mounted on the cross-pieces from which the secondary is suspended. and hence move with it. Small flexible cables should be used to connect to the secondary, and these should be of ample length, so as not to interfere with the free movement of the sliding coil.

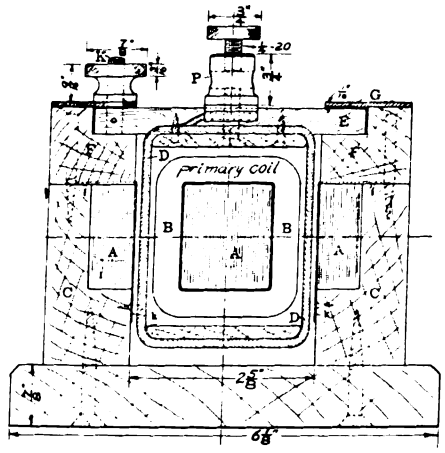

FIG. 3.—SECTIONAL VIEW OF TRANSFORMER.

The primary winding is designed for 100 volts and 60 cycles, and the secondary for approximately 5 volts. Of course, the secondary can easily be wound for higher voltages, but the transformer was originally built with a 5-volt secondary, as this voltage is ample for the operation of cautery knives. The transformer will operate equally well on 125 cycles; in fact, it runs cooler on the higher frequency, because of the lower magnetic density and smaller magnetizing current.

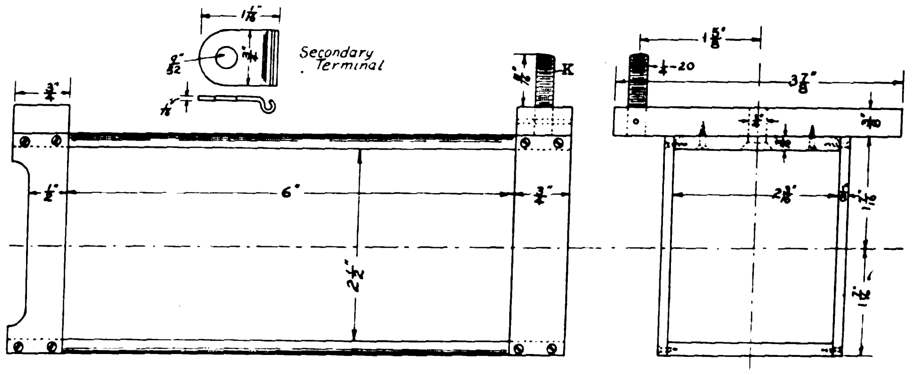

FIG. 5.—FRAME FOR SECONDARY WINDING.

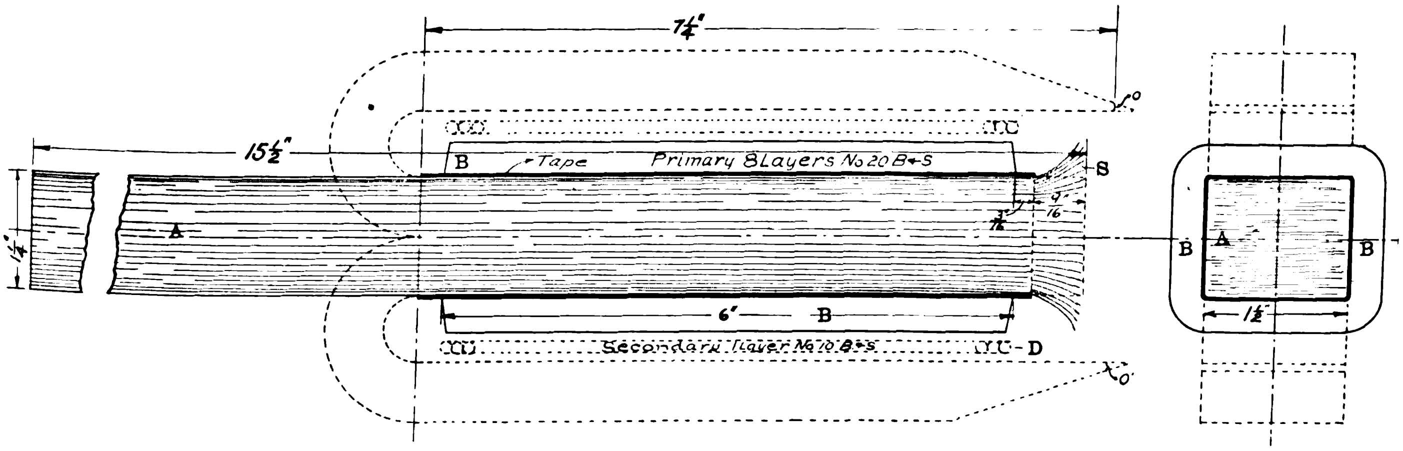

FIG. 4.—LAMINATED CORE OF TRANSFORMER.

The laminated iron core, Fig. 4, is built up out of thin annealed iron strips of a thickness anywhere from 0.014 inch to 0.020 inch. The thinner iron is to be preferred and is not so springy. Since ordinary sheet iron is liable to be quite hard and therefore give a large hysteresis loss, the strips should be well annealed by heating them to redness and allowing them to cool very slowly. It is not necessary to place insulation between the strips or even coat them with japan; the coating of oxide on the iron affords sufficient insulation to prevent eddy currents. The strips should be cut 1½ ins. wide, and should be flat and straight so that they will lay close together. It was found that for a transformer of this type and capacity about 1.75 square inches cross-sectional area of core was sufficient. The strips should therefore be built up to a thickness of 1¼ ins. This will give just 1.875 sq. ins. gross area so that the net sectional area of iron in the core will be about 1.75 sq. ins., allowing for the space between the strips not actually occupied by iron. After the strips have been assembled they should be clamped firmly together at one end by means of wooden clamps or some other suitable clamping arrangement and, while clamped, wound with two layers of strong tape, each layer half lapped. This tape should be started about 9-16 in. from the end of the core and wound back for a distance of 6½ inches. As each layer is applied it should be thoroughly soaked with insulating varnish and allowed to dry; after the second layer has dried, the primary winding may be applied. This tape, when dry, holds the core firmly and also serves to insulate the primary coil from it. Care should be taken to get this tape wound on evenly so that there will be no irregularities to cause humps in the primary winding.

The number of turns for the primary winding is determined from the well known transformer formula:

$$E = 4.44\,\Phi\,T\,f\,10^{-8}$$

where E = voltage, Φ = magnetic flux, T = turns, f = frequency. The iron core has a net sectional area of 1.75 sq. ins.; in order to make the magnetizing current and hysteresis loss small, the calculations for the primary will be based on the comparatively low magnetic density of 20,000 lines per square inch. This makes $\Phi = 20{,}000 \times 1.75 = 35{,}000$ lines. The frequency, $f = 60$ and $E = 100$, hence,

$$T = \frac{100 \times 10^8}{4.44 \times 35{,}000 \times 60} = 1073.$$

The primary winding is to be of No. 20 double cotton-covered wire. This wire has a cross section of 1021 circular mils, and has been found to work without overheating on the intermittent service for which this transformer is intended. It is necessary to make the space occupied by the primary as small as practicable, and on this account a smaller cross-section of wire is used than would be allowable in an ordinary transformer. Moreover, the ventilation is good, and this offsets to a considerable extent the small cross-section of copper per ampere in the primary. The primary winding is located as shown in Fig. 4, and consists of 8 layers of wire. The winding takes up a space of 6 inches along the core, and each layer contains on the average about 140 turns, making the total number 1120. This is slightly above the calculated number, but this will be all the better since the increased number will keep down the magnetizing current.

By clamping the projecting part of the core in two or three places, it can be made stiff enough so that the primary coil can be wound in a lathe. The winding must start at the left-hand end so that both of the coil terminals will come out at that end. The first layer should extend for 6 in. along the core, and each succeeding layer should be a little shorter so that the ends can be coned up and held by thin silk tape woven under the last three or four turns of each layer. Each layer, as it is wound on, should be thoroughly coated with insulating varnish and great care should be taken to secure a smooth and even winding. It is important that the winding be neatly done, because the secondary coil must slide over it and it is desirable to have the clearance between the two as small as possible. Unevenness of the primary winding at any one point makes the winding as bad for the present purpose as if it were uneven throughout. The ends of the primary wire should be carefully tied so that they cannot work loose and they should also be taped back for two or three inches from the coil.

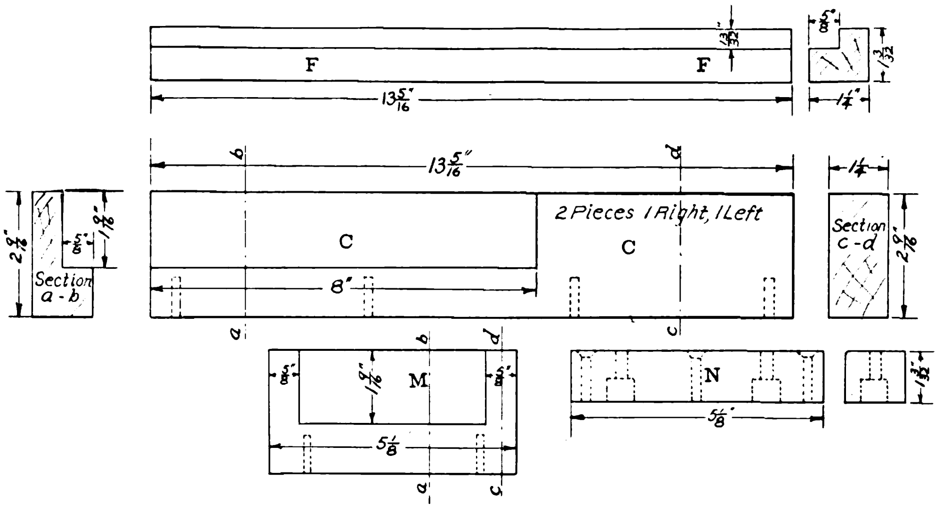

FIG. 6.—DETAILS OF SIDE AND END PIECES FOR TRANSFORMER.

After the primary has been wound, each iron strip of the core must be bent back as shown by the dotted outline in Fig. 4, one-half of the strips being bent around to one side of the primary and the other half to the other side. The strips should be bent around a round iron rod so as to secure an even and symmetrical core. On account of the springiness of the strips, it will be found almost impossible to make the core take the shape indicated by the dotted outline, but after it is placed in its supports it is easily held to this shape. The ends of a few of the strips should be clipped off as shown at *O O'* to avoid sharp ends on the core, and the strips at *S*, where they project beyond the taping, should be spread out so as to reduce the magnetic reluctance as far as practicable. This form of core gives a closed magnetic circuit, except for the two air-gaps at the ends necessary for the movement of the sliding secondary.

The secondary is wound on a light frame made of hard maple, of the construction and dimensions shown in Fig. 5. The frame is open at the sides and consists simply of top and bottom pieces connected by strips at each corner. The parts of the frame should be fastened together with small screws and glue. The frame should be slid over a rectangular block which can then be placed in a lathe and the secondary coil wound over it. The secondary consists of a single layer of No. 10 B. & S. wire double cotton covered, which must be wound on tightly, and after winding should be given three or four coats of insulating varnish both inside and outside. The wire must also be wound evenly so that the sides of the coil will be straight and uniform. The secondary coil will contain about 54 turns, if the wire is wound on straight and even. The ends of the wire are soldered to terminals made of 1-16 in. sheet copper of the shape shown in Fig. 5. These are clamped under the secondary binding posts, as shown in Fig. 1. The secondary binding posts should be substantial, as they have to carry a rather heavy current at times; a good binding post can be made of 7/8-in. brass rod, as indicated in Figs. 1 and 3.

The method of mounting the coils and core will be understood by referring to Figs. 1 and 2. On the wooden base, made of 7/8-in. hardwood, are screwed the two side pieces, *C, C,* and the end piece *M*. All the woodwork is made of hard maple, which can be oiled and polished if a good finish is desired. The side and end pieces are shown in detail in Fig. 6, and are fastened to the base by means of wood screws. After these pieces have been fastened to the base, the core and primary coil are placed in position as shown in Fig. 1. The sides of the core are held in place by thin brass pieces, *k, k,* Fig. 3, which hold the strips back in the groove. If desired, the sides of the core can be taped to hold the strips together, but this is not necessary if the strips have been properly bent. After the core has been fixed in place so that the primary occupies a central position, the strips *F, F,* shown in detail in Fig. 6, are screwed down, the primary binding posts are connected to the terminals of the winding, and the piece *N* is screwed down. After the secondary coil has been slid into position, the brass strips *G, G* are screwed in place. One of the brass strips has a slot *H* to receive the stud on the secondary sliding frame. The parts should be adjusted so that the secondary coil will slide freely without binding and clear the primary coil at all points.

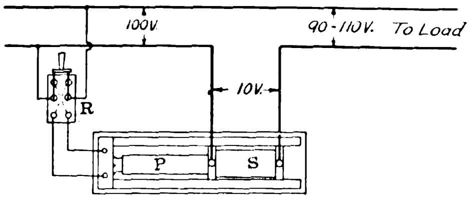

FIG. 7.—DIAGRAM OF CONNECTIONS.

The transformer will be found useful for any experimental work requiring an alternating current at low voltage. Where it is used for experimental purposes it is a good plan to make two or three secondary coils having different numbers of turns; thus, a coil having about 115 turns will give approximately 10 volts. Coils with any desired number of turns can be made up so long as the winding does not take up more space than that shown in the sketches. It takes but a few moments to change the secondary coil, and in this way a wide range of secondary voltage can be secured. With the secondary wound with No. 10 wire, the transformer will deliver a current of 20 to 25 amperes for short intervals, and 10 amperes continuously.

The transformer can also be used as a voltage regulator by connecting it as shown in Fig. 7. The primary, *P*, is connected to the mains through a simple reversing switch, *R*, and the secondary, *S*, is connected in series with one of the mains. The secondary voltage can thus be added to or subtracted from the primary voltage, depending upon the position that *R* occupies. Thus if the secondary is wound for 10 volts and the transformer operated on 100 volts, voltages of any value from 90 to 100 can be obtained with one position of the reversing switch and from 100 to 110 with the other position.

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SOME NOTES ON THE HUNTING OF ROTARY CONVERTERS.

BY CLARENCE P. FOWLER.

A rotary converter when converting alternating current to direct current operates as a synchronous motor, and as such is subject to the action known as "hunting" or "pumping," common to all synchronous apparatus under certain conditions. This hunting is an alternate acceleration and retardation of the motion of the armature or rotating member. It is accompanied by the shifting of the magnetic lines of force across the polar arc, thus shifting the effective field alternately ahead and behind of its normal position, with a consequent change in the location of the neutral point on the direct-current commutator of the machine and thereby oftentimes causing vicious sparking at the commutator brushes.

The speed of a rotary converter, like that of a synchronous motor, is determined by the frequency of the supply circuit, and tends to follow any irregularities in frequency which the circuit may possess. The fluctuation of frequency in a circuit supplying rotary converters may be due to various causes, among the most common of which is variation in the angular velocity of the prime-mover, driving the supply alternator. This variation in angular velocity, in the case of an engine-driven outfit, is sometimes due to a badly-working governor, which tends to hunt about a point of equilibrium.

A far more frequent cause of hunting than the above is an alternator of poor inherent regulation. Such an alternating-current generator will usually be found to have a comparatively small air-gap, a relatively large number of armature ampere-turns compared with those of its field winding, and the armature windings are frequently of the unicoil type, and therefore have a high self-induction as compared with a distributed winding. All of these features are conducive to poor regulation. Since the armature ampere-turns, in an alternator of this type, may have a maximum influence upon its field, and since the effective magnetic field is the resultant of the armature and field currents, it is evident that an armature current of varying power factor may shift the effective magnetic field back and forth across the pole faces. Hence, the equivalent of a fluctuation in speed may be produced even when the speed is constant.

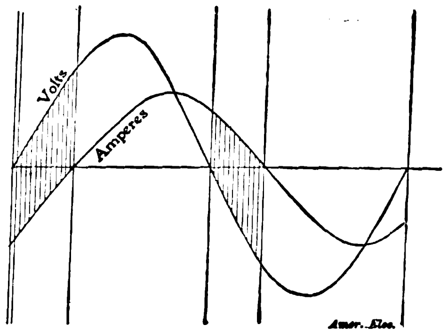


FIG. I.

There is also a tendency towards the variation of angular velocity of the prime-mover during the flow of currents of low power factor, these currents being in such a phase relation with regard to the e.m.f. as to produce an alternate motor and generator action twice in every cycle. Referring to Fig. 1, it will be noted that during the interval represented by the shaded portions of the curves of voltage and current, these two quantities are in opposition, and therefore represent motor action by the alternator, or a tendency to assist the prime-mover. The unshaded portions show the current and e.m.f. to be of the same sign, and therefore represent generator action, giving rise to a torque resisting the motion of the prime mover.

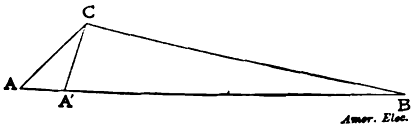


FIG. 2.

Changes in voltage may sometimes be the cause of hunting in a circuit which is supplied from an alternator running at a speed quite uniform. For each alternating-current voltage applied to a rotary, there is a definite angular relation between the stationary poles of the field magnet and the poles formed on the armature by the armature currents. A change in voltage will vary somewhat the relative position of the otherwise interlocked armature and field poles. This will usually cause the rotary to draw a somewhat different current, which changed current will effect a change in the drop between the generator and the rotary, which means a new applied voltage at the rotary collector rings. Furthermore, a different angular relation is brought about between the armature and the field magnet. This phenomenon is obviously cumulative and may obtain for sometime under varying voltages, being sometimes serious enough to cause a rotary to fall out of step.

This condition may be simply represented by e.m.f's *A*, *B*, *C*, Fig. 2, in which *A B* represents the applied alternating e.m.f.; *B C*, the counter e.m.f., which is proportional to the field strength of the rotary, and *A C* is the resultant of the two. By decreasing the applied e.m.f., *A B* to *A' B*, the counter e.m.f. or field strength of the rotary remaining the same, it is plain that the resultant e.m.f., *A' C*, is also changed, and consequently the current dependent on it.

Hunting may evidently also be induced in a rotary converter which is connected to a system on which other synchronous apparatus is behaving badly, in just the same manner as though the fluctuations were produced by abnormal conditions at the generator.

Finally, the simplicity in the construction of the rotary element of the rotary—being a cylindrical mass of metal turning about its axis—lends itself somewhat readily to the speed-changing conditions of the circuit. Contrasting this simplicity of the rotary armature with that of the moving element of an alternator, it is evident that before hunting can exist in the case of the latter it is necessary that a complex and relatively massive system be put in oscillation, whereas the weight and contour of a rotary armature are favorable in fluctuations in frequency.

The foregoing are some of the most important causes of troubles experienced in the hunting of rotary converters, and these may be almost all prevented, if not entirely so, in the design of the supply generators and rotaries, providing the engines possess the necessary speed regulating qualities.

BOILER SETTINGS.

BY CHAS. L. HUBBARD.

Foundations.—The first requirement of a good boiler setting is a substantial foundation. Where the soil is firm this may be made either of concrete or of rough stone laid in cement. The foundation walls should be at least 16 inches wider than the walls of the setting which they support, allowing 8 inches on each side. In the case of heavy settings for power work the foundation may be made from 20 to 24 inches wider than the wall of the setting, and in some cases a solid bed of concrete large enough to support the entire setting is provided. The depth of the foundation is usually 20 to 24 inches for boilers up to 48 inches in diameter, and from 24 to 28 for larger sizes. These dimensions are only applicable where a solid earth footing is available, much heavier foundations being required if the earth is soft or yielding. If concrete be used it should be of the best quality.

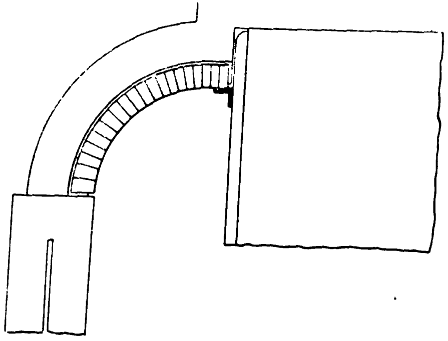


FIG. I.—ARCH BAR FOR BOILER SETTING.

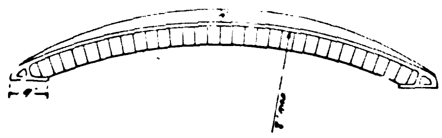


FIG. 2.—STANDARD HARTFORD ARCH BAR.

Brickwork.—The setting should be of hard burned brick laid in freshly made cement mortar, containing two parts of cement to one of sand. The furnace, bridge wall and arching over the rear connection or combustion chamber should be lined with firebrick laid in pine cement or a mixture of fireclay and ground firebrick, with very close joints. In setting boilers for power work it is customary to line the space exposed to the fire and hot gases with firebrick, and this is often done in the case of heating boilers in plants of considerable size. The outer walls should be made double with an air space between to reduce the conduction of heat as much as possible.

Arch Bars.—One part of the setting which requires special care, is the construction of the arch over the back connection, where the setting closes up against the back head of the boiler. This is sometimes turned from the back wall forward, as shown in Fig. 1. An angle iron is either riveted to the boiler head or supported in the side walls of the setting for the front of the arch to rest upon. The firebrick lining is held in position by cast-iron arch bars and the whole construction covered with firebrick. A space of at least an inch should be left between the arch and the end of the boiler to allow for expansion. One objection to this form of arch is the exposed position of the angle iron support, which is liable to be injured by contact with the hot gases which pass over it. The effects of expansion and contraction of the boiler and setting are more apt to weaken the arch when made in this way than when it is sprung from the side walls. In this case, the arch is supported by bars so designed that a very limited part of the metal is exposed to the direct heat of the furnace gases. The form of bar used in the standard "Hartford" setting is shown in Fig. 2; it consists of a curved piece, of the dimensions shown. The bricks are laid up against the bar in an arch and are held in position at each end by projections cast upon the bar. In Fig. 3 the arches are shown in position. Three of them arranged side by side are sufficient to cover the space between the boiler and the rear wall, in most cases. The ends of the iron supporting bars rest upon the side walls of the setting, and the rear wall is built around the arch as shown. Before placing the firebrick in the arch bar, it should be turned bottom upward. If arch bricks, curved to an 8-ft. radius, can be had they should be used; if not, common firebrick will answer the purpose; but in this case every third or fourth brick should beveled so that no large spaces will be left between them when they are in position. The last brick to be put in is the key brick, and must necessarily be driven in endwise. After the bricks have been carefully fitted in position they should be removed, then wet, coated with a thin paste of fireclay and water, and put in place in the bar. The bar with the bricks in position should next be turned right side up, and the spaces between the bricks filled with a paste made of fireclay, ground firebrick and water. After the whole has dried and hardened, the arch may be placed in position on the setting.

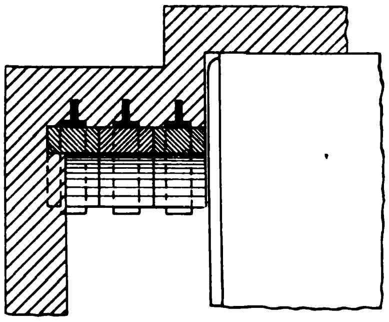


FIG. 3.—ARCH BARS IN POSITION.

Covering.—The top of the boiler is protected in some cases by springing a brick arch over it, leaving an air space of an inch or two between the brickwork and the shell; but ordinarily light burned brick are placed loosely upon the side over the boiler shell, these in turn being covered with a layer of hard brick laid in cement mortar.

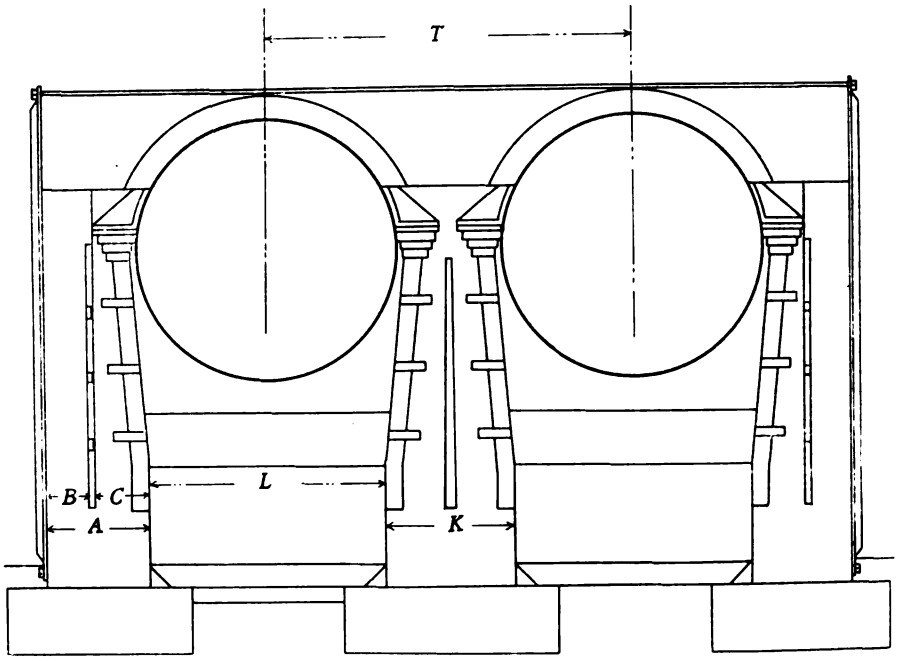


FIG. 4.—FRONT VIEW OF BOILER SETTING.

Iron Work.—From three to five pairs of buck stays with tie rods should be provided to prevent the outer walls from spreading. Heavy cast-iron plates, about 20 inches in length, and planed upon the upper surface, should be placed upon the side walls for the lugs or brackets to rest upon. Three iron rolls one inch in diameter should be placed beneath each bracket, except the front ones, for the boiler to move upon when it expands and contracts. Special care should be taken to leave a clear space back of each movable bracket to allow freedom of expansion without bringing excessive strains on the brickwork. The boiler front is of cast-iron, and is provided with doors for access to the tubes, furnace and ash-pit. Table I gives dimensions for both light and heavy settings, and is to be used in connection with Figs. 4, 5 and 6. The distance on centers between the boilers, as given in the table, is based on the assumption that the projection of the brackets from the boiler shell does not exceed the figures given in Table I-A.

TABLE I-A.

Diameter of boiler.	Maximum projection of brackets.
42 ins.	9 ins.
48 ins.	9 ins.
54 ins.	10 ins.
60 ins.	10 ins.
66 ins.	12 ins.
72 ins.	12 ins.

If the projection is greater than that given above, the thickness of the division wall must be increased correspondingly.

TABLE I.—DIMENSIONS FOR BOILER SETTINGS.

	Heavy Setting, for Power.								Light Setting, for Heating.							
Diameter.	30"	36"	42"	48"	54"	60"	66"	72"	30"	36"	42"	48"	54"	60"	66"	72"
A	22	26	26	26	30	30	30	30	22	22	22	22	22	22	26	26
B	8	12	12	12	12	12	12	12	8	8	8	8	8	8	8	8
C	12	12	12	12	16	16	16	16	12	12	12	12	12	12	16	16
D	7	7	7	7	11	11	11	11	7	7	7	7	7	7	11	11
E	8	8	8	12	12	12	12	12	8	8	8	8	8	8	8	8
F	12	12	12	12	12	12	12	12	8	8	8	12	12	12	12	12
G	8	8	8	12	12	12	12	12	8	8	8	12	12	12	12	12
H	22	22	22	26	26	26	26	26	18	18	18	22	22	22	22	22
I	24	24	24	28	28	28	28	28	20	20	20	20	24	24	24	24
J	8	8	8	8	9	9	10	10	8	8	8	8	9	9	10	10
K	24	28	28	28	32	32	32	32	24	26	26	26	28	28	28	28
L	24	30	36	42	48	54	60	66	24	30	36	42	48	54	60	66
M	20	22	22	24	24	24	24	24	20	22	22	24	24	24	24	24
N	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
O	22	22	24	24	24	24	24	24	22	22	24	24	24	24	24	24
P	24	24	24	24	24	24	28	28	24	24	24	24	24	24	28	28
W	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
R	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
S	2-10	3-4	3-10	4-4	4-10	5-4	5-10	6-4	2-10	3-4	3-10	4-4	4-10	5-4	5-10	6-4
T	4-0	4-10	5-4	5-10	6-8	7-2	7-8	8-2	4-0	4-8	5-2	5-8	6-4	6-10	*7-10 7-4	8-4 7-10
Length of Setting = Length of tubes +	3-6	3-8	3-8	4-2	4-2	4-2	4-2	4-2	3-2	3-4	3-4	3-10	3-10	3-10	3-10	3-10
Width of setting—1	5-8	6-10	7-4	7-10	9-0	9-6	10-0	10-6	5-8	6-2	6-8	7-2	7-8	8-2	9-10 9-4	10-4 9-10
Width of setting—2	9-8	11-8	12-8	13-8	15-8	16-8	17-8	18-8	9-8	10-10	11-10	12-10	14-0	15-0	17-8 16-8	18-8 17-8
Width of setting—3	13-8	16-6	18-0	19-6	22-4	23-10	25-4	26-10	13-8	15-6	17-0	18-6	20-4	21-10	25-6 24-0	26-6 25-0
Width of setting—4	17-8	22-4	23-4	25-4	29-0	31-0	33-0	35-0	17-8	20-2	22-2	24-2	26-8	28-8	33-4 31-4	34-10 32-10

* Upper figures to be used when width of grate equals diameter of boiler.

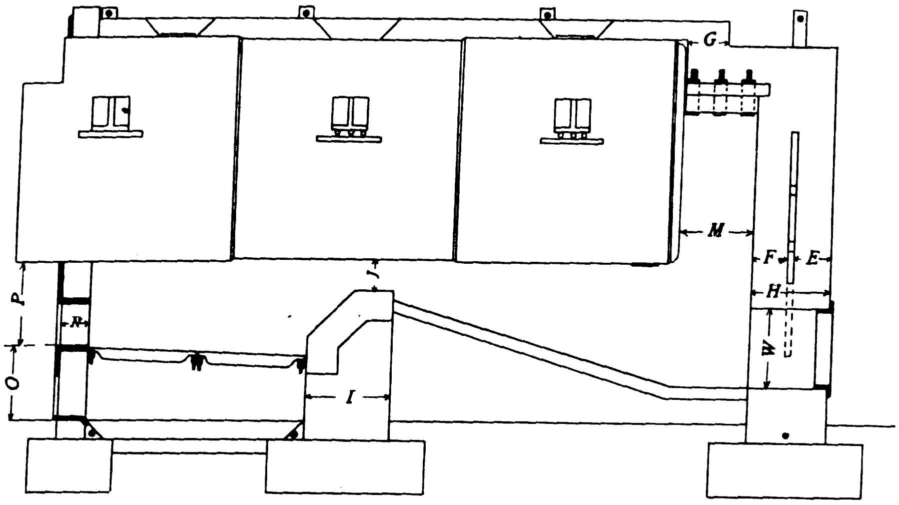


FIG. 5.—SIDE VIEW OF BOILER SETTING.

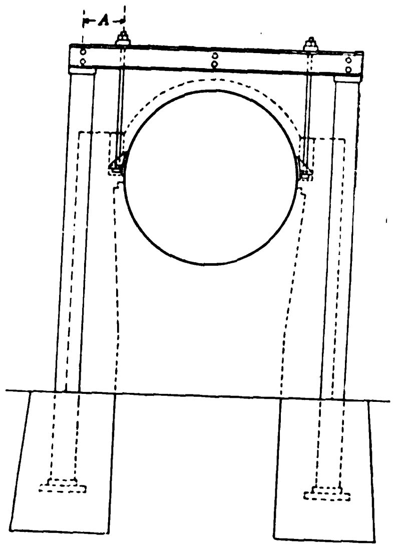


FIG. 7.—FRONT VIEW OF A GALLOWS FRAME SUPPORT.

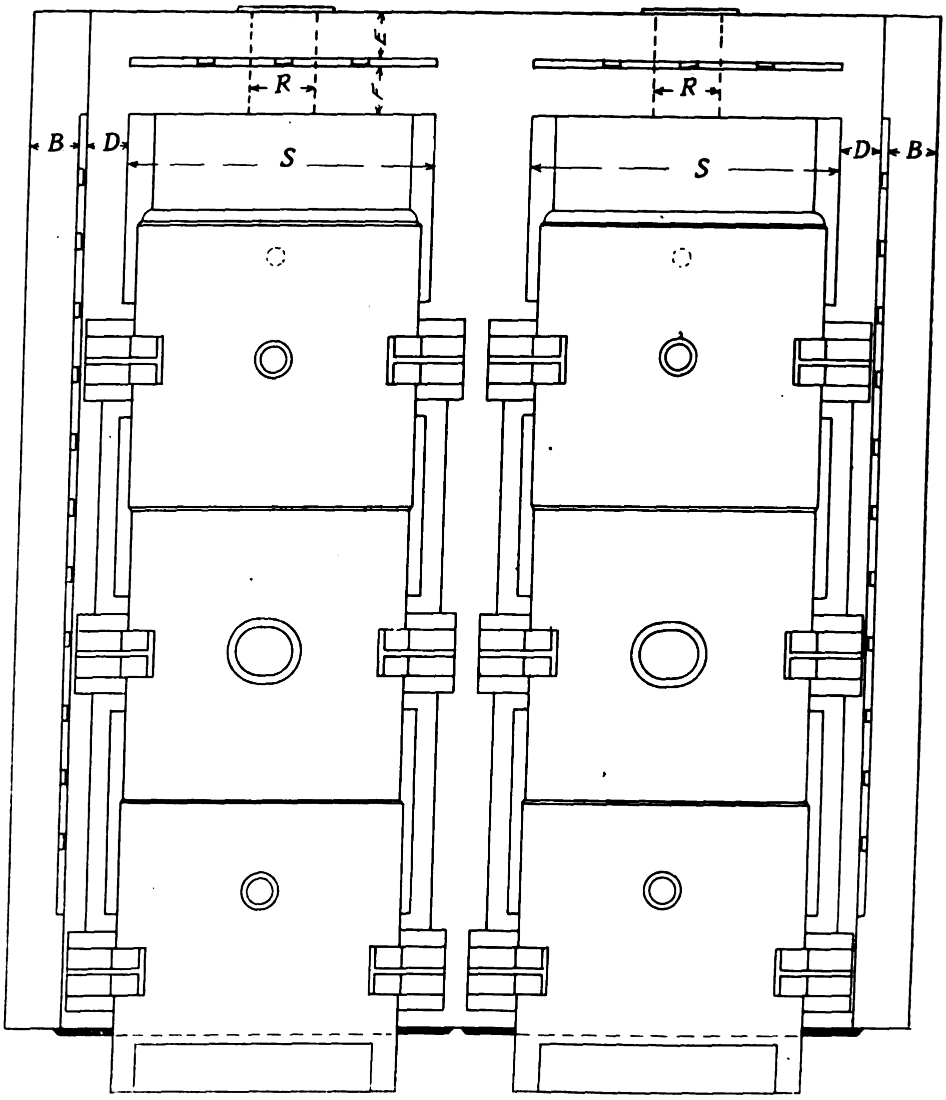


FIG. 6.—PLAN VIEW OF BOILER SETTING.

Gallows Frame Supports.—A form of support for tubular boilers which is coming into common use is the metal gallows frame. Boilers supported in this manner are entirely independent of the brickwork, and when properly erected, expansion may take place without injury to the walls, which gives this form of setting a decided advantage over the common form. There are several ways of constructing a support of this kind, depending more or less upon the taste and skill of the designer. A very satisfactory arrangement, and one comparatively easy to construct, is shown in Figs. 7 and 8, which represent the end and side views, respectively, of a boiler supported in this manner. The four columns are of wrought-iron pipe, provided with flanges at the lower end and embedded from one-quarter to one-third of their length in concrete foundations. The girders are made up of either two I beams or of two channels placed back to back about 2 inches apart. Cast-iron caps are placed on the tops of the columns for the girders to rest upon. These caps should have some form of projection to which the girders may be bolted. The suspension rods which support the boiler extend upward between the two channels of the girder, and are provided with heavy nuts and washers. The washers distribute the load equally between the channels. Spacing blocks should be bolted between the channels near the suspension rods, or special casting with groove for fitting over the edges may be used instead. The channels may be still further stiffened by bolting them at the centre. The connection between the suspension rods and the boiler shell is made by means of a cast-iron lug or a loop and hook. In order to keep the front and rear girders the same distance apart and to still further strengthen the construction, it is well to put in two longitudinal struts, one over each side wall, as shown in Fig. 8. Channels may be used for this purpose, fastened to the girders by mean of angles and bolts. When two boilers are set in a battery the gallows frame may be made as indicated in Fig. 9, or the support for the second boiler may be a duplicate of that already described for a single boiler, the inner ends of the girders resting on the same column, which passes up through an opening in the division wall. The method shown in Fig. 9 is preferable on account of its simplicity, and the cost of the heavier girders and supports required is usually less than that of the extra columns and foundations. The method of proportioning the various parts is as follows:

Suspension Rods.—The weight of the boiler full of water, together with the piping which it supports, divided by 4 gives the load on a single rod, and this divided by 10,000 (the safe working stress per square inch) will give the required sectional area for a steel rod. As the end of the rod has a thread cut on it, it should be upset to a larger diameter so that the sectional area at the bottom of the thread is equal to or greater than that of the solid rod. The following table gives the necessary enlargement:

TABLE II.

Diameter of rod.	End upset to	No. of threads per in.
1 in.	1⅜ ins.	6 ins.
1⅛ ins.	1½ ins.	6 ins.
1¼ ins.	1⅝ ins.	5½ ins.
1⅜ ins.	1¾ ins.	5 ins.
1½ ins.	2 ins.	4½ ins.
1¾ ins.	2¼ ins.	4½ ins.
2 ins.	2½ ins.	4½ ins.

Girders.—To determine the size of girder for a single boiler, multiply the load in pounds on a single column (one-quarter the weight of boiler, etc.), by the distance in inches from its centre to the adjacent suspension rod (see *A* in Fig. 7). This gives the bending moment, which in turn divided by 10,000 pounds, for steel, gives a quantity known as the section modulus. The following table gives the section modulus for different sizes of channel bars, from which the required sizes can be selected after determining the section modulus as above described. It should be borne in mind, however, that the load is equally divided between the two channels, so that the section modulus of each need be only one-half that computed for the whole girder.

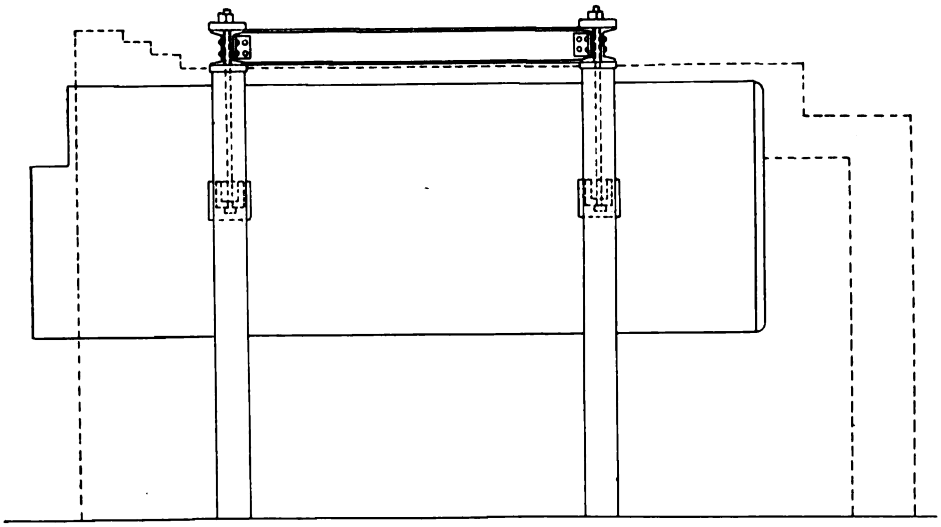


FIG. 8.—SIDE VIEW OF A GALLOWS FRAME SUPPORT.

If heavier girders are required than can be formed by the channels given above, I beams may be used. The section modulus for these may be found in any handbook issued by the manufacturers of iron beams. For double settings (see Fig. 9) the load on each suspension rod is the same as for a single boiler; but the load on each column is twice as great. To find the bending moment in this case, multiply the load on a single column (one-quarter the weight of two boilers) by the distance *B*, Fig. 9, then multiply the load on a single suspension rod (one-quarter the weight of one boiler) by the distance *C*, and subtract the second product from the first, the remainder is the bending moment sought. Having determined the bending moment, the required size of girder channels is found as before.

TABLE III.

Size of channel.	Weight per ft.	Section modulus.
6 ins.	8 lbs.	4.3
7 ins.	9¾ lbs.	6.0
8 ins.	11¼ lbs.	8.1
9 ins.	13¼ lbs.	10.5
10 ins.	15 lbs.	13.4
10 ins.	20 lbs.	15.7
12 ins.	20½ lbs.	21.4
12 ins.	25 lbs.	24.0
12 ins.	30 lbs.	26.9
15 ins.	33 lbs.	41.7
15 ins.	35 lbs.	42.7

Columns.—The diameter of the pipe columns may be made the same as the depth of the channels. This makes them amply strong for the load they have to support, and also gives a good appearance. The following table gives the approximate weights of different sizes of boilers full of water, together with such of the piping as may be supported by the boiler.

The walls in this type of setting may be lighter than in the ordinary setting where they are required to support the weight of the boiler. Two 8-in. walls with a 2-in. air space between them will usually be sufficient. The foundations may also be shallower, 16 to 20 inches being sufficient where there is a good earth footing. The piers supporting the columns should extend 18 to 28 inches below the bottom of the columns. For a solid earth footing of well-packed gravel, the dimensions given in Table V may be chosen.

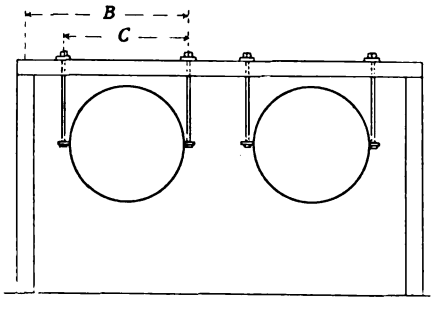


FIG. 9.—GIRDERS FOR DOUBLE SETTING.

TABLE IV.

Diameter.	Length.	Approx. wt.
48 ins.	12 ft.	12,000 lbs.
48 ins.	14 ft.	14,000 lbs.
48 ins.	16 ft.	16,000 lbs.
54 ins.	13 ft.	15,500 lbs.
54 ins.	15 ft.	18,000 lbs.
54 ins.	17 ft.	20,500 lbs.
60 ins.	14 ft.	20,000 lbs.
60 ins.	16 ft.	23,000 lbs.
60 ins.	18 ft.	26,000 lbs.
66 ins.	15 ft.	28,000 lbs.
66 ins.	17 ft.	31,500 lbs.
66 ins.	19 ft.	35,000 lbs.
72 ins.	16 ft.	35,000 lbs.
72 ins.	18 ft.	39,000 lbs.
72 ins.	20 ft.	43,500 lbs.

TABLE V.

Diam. of boiler.	One boiler, size of piers.	Two boilers, size of piers.
48 ins.	18x20 ins.	24x24 ins.
54 ins.	18x24 ins.	24x30 ins.
60 ins.	24x24 ins.	25x36 ins.
66 ins.	24x30 ins.	32x36 ins.
72 ins.	24x36 ins.	36x40 ins.

◆

A COMMON BATTERY PRIVATE BRANCH EXCHANGE.

BY A. DALLAM O'BRIEN.

The private branch exchange has come to be recognized in the telephone world as a most important adjunct to the central office, and the constantly increasing number being installed by telephone companies all over the country furnishes a striking testimonial as to the usefulness of these small switchboards in the field which they occupy. The capacity for which such boards are built has gradually increased until at the present time a switchboard of this type having a capacity of 200 lines is by no means unusual. It is the purpose of this article to describe a board which has been very largely used by a prominent company and which has given great satisfaction.

In Fig. 1 is shown a front elevation and a side section of a private branch exchange switchboard having a capacity of 200 lines, which will be divided into two classes: First, connecting lines between the switchboard and local sub-stations, and, second, trunk lines leading from the branch exchange to the central office. The relation between the number of local and trunk lines will naturally vary in different cases; in the present instance the board will be considered as equipped with 180 sub-station lines and 20 trunk lines.

In a branch exchange of this capacity the volume of local traffic which must be handled through the board is usually considerable, and neglecting the incoming and outgoing trunk-line calls, the connections to be handled would impose too heavy a task upon a single operator; consequently, the board is divided into two operator's positions, each position having an equipment of 90 sub-station lines and 10 trunk lines. The board may be equipped with a maximum of 15 pairs of connecting cords per position, it being more usual, however, to use 12 pairs of cords, as is the case with the board shown in Fig. 1. The switchboard itself is built of mahogany or oak to conform with its surroundings, and the case is about 5 ft. long, 5 ft. high, and 3 ft. deep from the front of the keyboard to the back of the casing. The rear doors and the front panels under the keyboard are removable, so as to allow of easy access to the interior. The auxiliary apparatus used in connection with the various circuits is mounted in the interior of the case, the absence of the usual connecting rack allowing ample room for this purpose.

The line and trunk jacks are mounted in strips of 10 each in the face of the board, 5 such strips comprising a panel, there being two panels to each operator's position.

The strips are about ½-in. thick, and the individual jacks are on 1-in. horizontal and ½-in. vertical centres. The line signals consist of 80-ohm magnetic signals, mounted in strips of 20; four complete strips and one strip containing 10 signals being required for each operator's position. These signals are not of the drop type, but have attached to the magnet armature a lever which, when the armature is attracted, serves to raise a small aluminum shutter upon which is stenciled the number of the line to which it belongs. The signals are mounted in the interior of the board and project through to the face, being covered by a glass plate as indicated in Fig. 1. The signals on the trunk lines to the central office consist of 500-ohm tubular drops, the drops for each position being mounted on a strip and set in the board immediately above the line and trunk jacks, as shown.

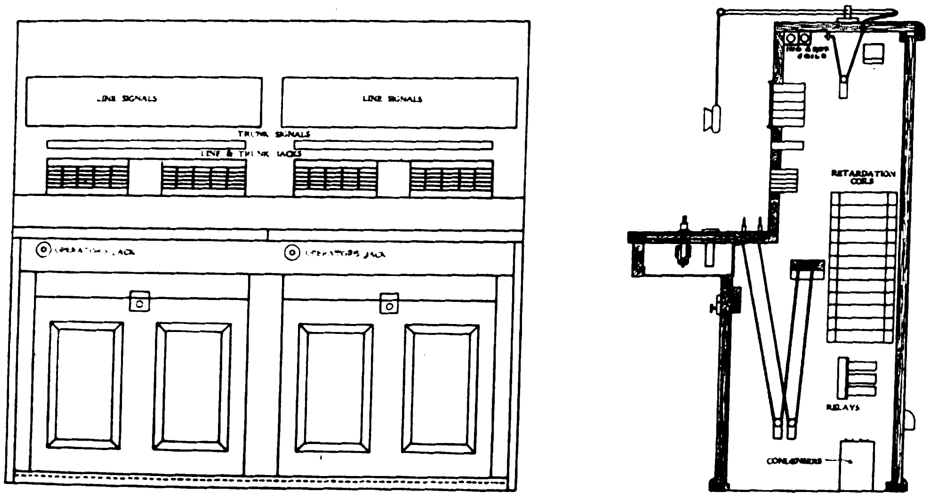


FIG. 1.—FRONT ELEVATION AND SIDE SECTION OF A 200-LINE PRIVATE BRANCH EXCHANGE SWITCHBOARD.

The cord circuits are equipped with two ringing keys and one listening key, and, in addition, one visual supervisory signal is provided for each pair of cords, the supervisory signals being mounted in the keyboard, as shown, and covered on the outside by a glass plate. In each cord circuit is also a controlling relay and a double-wound retardation coil. The relays are mounted on a steel plate which extends across the interior of the board. There are also mounted on this plate a number of 30-ohm resistance coils, one such coil being used in each trunk circuit, as will be explained later.

The retardation coils consist of two 40-ohm windings wound over the same core and completely enclosed in a cylindrical iron cover about 1-16 in. thick. The cover is mounted on a wooden base and the four terminals of the coil brought out, two at either end, and connected to lugs mounted on the base. These coils are mounted in a special rack fastened to the side of the switchboard, the position of the coils being clearly shown in Fig. 1. The condensers, for which room must be found in the interior of the switchboard case, consist of one for each trunk circuit and two for each operator's circuit, having a capacity of 2 microfarads each, and one of 10 microfarads capacity. These are placed side by side in an upright position in the bottom of the case, as shown by Fig. 1, and are held in place by brass straps fastened to the sides and bottom of the case. The induction and retardation coils in the operator's circuit and the night bell or buzzer are mounted on the side of the case near the top, as shown.

The cord shelf is of the usual type, made of 1-in. maple, 4 ins. wide, and extending across the interior of the case. As there is no provision for a connecting rack in the case itself, a connecting box is provided, which is usually located as near to the switchboard as possible. In this box are terminated all the local and trunk lines coming to the switchboard, and by means of cross-connecting wires, are connected to 20-pair switchboard cables which lead to the board. The cables are brought up the side of the board to the jacks, where they are fanned out, and the pairs soldered to the outer springs of the four-point jacks. From the inner springs of the local line jacks a cable of No. 22 silk and cotton-covered switchboard wire is led to the terminals of the line signals and the pairs soldered thereto. A similar cable connects the trunk drops and the inner springs of the trunk jacks. With this cable it is necessary to run a leg down the side of the switchboard in order to take in the condensers, one of which is wired in series with each trunk drop.

Before considering the method of operation of the switchboard, it might be well to examine the wiring of the different circuits. In Fig. 2 is shown a wiring diagram for the connecting cords and operator's telephone circuits. Current is usually furnished to the board from the central office, the only instances in which storage batteries have been used at the branch being those in which the distance from the board to the central office was so great that an excessive number of cable conductors would be required to supply the current needed at the switchboard without an excessive drop in potential; the e.m.f. at the branch must be maintained at a minimum of about 12 volts. Current is furnished to the cord circuits from the battery through the windings of the retardation coils and relay contacts, a coil and relay being provided for each cord circuit. The effect of this arrangement, as will be clearly seen from the drawing, is to connect the battery in parallel across to the cord circuit when the relay is not energized. The supervisory signal is connected in series in one side of the circuit and its winding is divided into two equal parts, the junction being tapped and connected to one of the relay contacts. Both the answering and calling plugs are equipped with ringing keys, so that the operator is enabled to signal with either cord.

Current for signaling purposes is usually furnished from the central office, although it is customary to equip the board with a hand generator to be used in case the ringing supply should be cut off due to some trouble. The operator's listening key is connected in the circuit as shown in the diagram, and the wiring of the operator's telephone set is in accordance with the standard Bell practice in cases where the transmitter is connected directly to the 24-

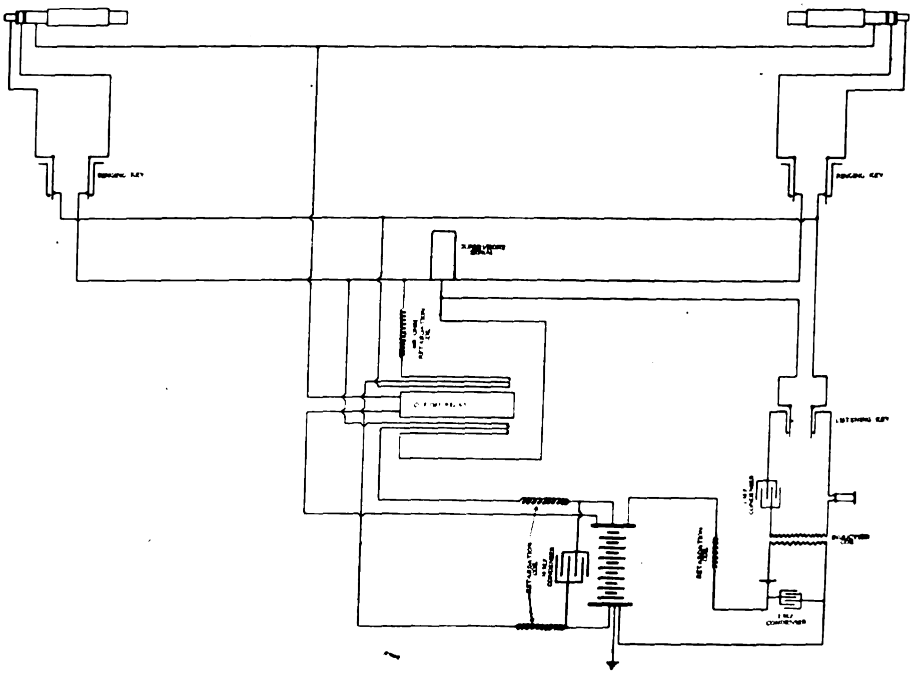


FIG. 2.—WIRING DIAGRAM OF CONNECTING CORDS AND OPERATOR'S TELEPHONE CIRCUITS.

volt battery. The method of wiring this circuit is clearly shown in the drawing.

In Fig. 3 is shown the wiring diagram for the local line circuit, the line signal being connected in series with the line and the battery through the inner contacts of the four-point jacks. It will be noticed in this circuit that the sleeve of the line jack is left unconnected, so that on calls between local instruments the relay in the cord circuit is not operated.

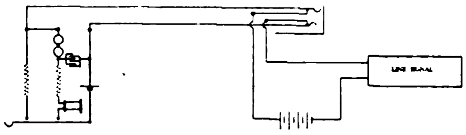


FIG. 3.—LOCAL LINE CIRCUIT.

Fig. 4 shows the wiring of a trunk line from the branch exchange to the central office, the central end consisting of the standard common battery arrangement and the branch end having a signal connected in series with the line and a condenser through the inner contacts of the jack, and in addition the sleeve of the jack is connected to ground through a 30-ohm resistance coil.

The operation in the case of calls between two stations connected to the branch exchange is as follows: The removal of the receiver from the hook at a calling station closes the circuit of the battery through the line signal, line and station instruments, thus causing the signal to display its target and notify the operator. The operator answers with the back cord of a pair, operates her listening key and ascertaining the connection desired, rings the required station by means of the ringing key connected to the front cord of the pair. Current for talking purposes is furnished to the stations through the retardation coils, relay contacts and split winding of the supervisory signal. During the time that the receiver at the calling station is removed from the hook the supervisory signal is energized and its target displayed in the keyboard before the operator. When the receiver at the calling station is hung up the supervisory target drops and the operator disconnects.

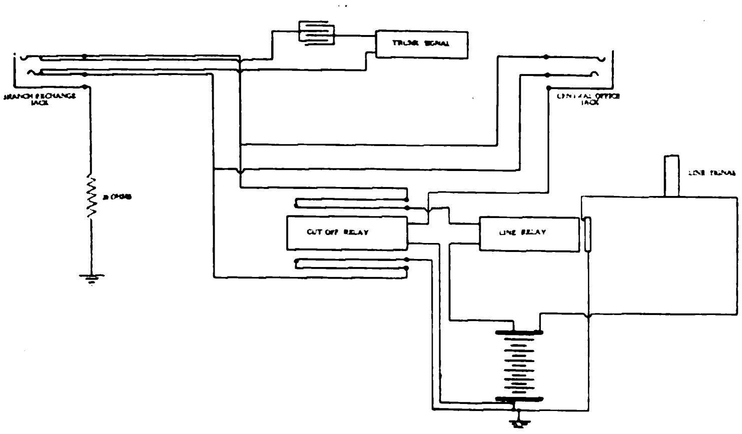


FIG. 4.—TRUNK LINE FROM BRANCH EXCHANGE TO CENTRAL OFFICE.

When a call originates at a station connected to the board which requires trunking to the central office for its completion, the branch operator, after ascertaining the connection desired in the usual way, calls the central office by placing the front plug of a pair in the jack of a trunk. This closes the circuit of the battery through the line relay at the main office, through the line to the branch, and thence through the 600-ohm retardation coil to ground the branch exchange. This coil is connected in the cord circuit when the relay is operated, which only occurs when a plug is inserted in the jack of a trunk line, current then flowing from the battery through the relay coil sleeve of plug and jack and through the 30-ohm resistance coil to the grounded side of the battery.

From the foregoing description it will be seen that on trunked connections current is furnished to the branch instrument through the cord at the central office, and at the same time, the battery supply at the branch is connected in parallel with the central office battery through the winding of the supervisory signal. As all connections to trunk lines are made with the front cord, it will be evident that the supervisory signal is controlled entirely by the local instrument which is connected on the back cord, and in consequence the local station is at all times enabled to signal the branch operator by working the hook switch. On incoming calls over trunk lines, the operator at the main office rings on a line to the branch, and thus operates the 500-ohm tubular drop through the condenser and signals the branch operator, who answers in the usual way. The insertion of the condenser in series with the trunk signal is done in order that the direct current from the central office may be kept from flowing continually through the signal and thus lighting the line signal at the main exchange and at the same time operating the branch signal. The alternating ringing current, however, readily passes through the condenser and thus operates the trunk signal when desired. The 10-microfarad condenser, which is bridged across the battery leads, is used for the purpose of keeping down cross-talk.

On local calls the calling party is instructed to keep the receiver off the hook until the connection is completed, and on trunk calls, is instructed to hang up the receiver after giving the necessary details to the branch operator. The branch operator obtains the station desired, and then signals the calling station, and for this reason both cords are equipped with ringing keys, thus allowing the operator to use one pair of cords in completing a trunk connection.

The night bell circuit is wired in the usual way, so that when the switch is closed the operation of a line or trunk signal will close the circuit through the bell and thus give an audible signal to the operator.

In cases where a capacity of 200 lines is more than sufficient, for the requirements to be met, these boards are built with one operator's position and equipped for 100 lines, the arrangement of apparatus and circuits remaining the same as in the board herein described.

◆◆◆

ERECTING TELEGRAPH LINES UNDER DIFFICULTIES.

The following account of some experiences of the United States Signal Corp with the Lake Lanoa military expedition was sent to us from Manila by a member of the telegraphic staff accompanying the expedition, and serves to indicate how success may be achieved under the most adverse conditions if a man only "knows how" and has the necessary grit and endurance. The Lake Lanoa expedition entered the Moro stronghold in the interior of the island of Mindanao and captured several strong forts before peace was established; lines for telegraphic communication with the base of supplies had to be put up, of course, as the expedition advanced, crude facilities and dangerous surroundings making the work about as difficult as it could well be within the limits of possibility. The narrative of our correspondent follows:

The difficulties experienced in establishing the lines will never be forgotten by those men in the signal corps. It was difficult to secure supplies; the pack trains had all that they could possibly do to furnish rations and ammunition for the troops. We had native packers at first, but these fellows constantly deserted until all were gone, and we had to rely upon soldiers for assistance. We were always exposed and were frequently fired upon.

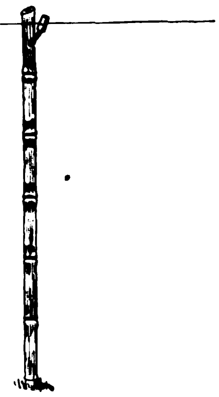


FIG. 1.

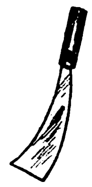


FIG. 2.

Poles of bamboo were readily obtainable, but these poles are good for service for a limited time only. The natives understand the art of selecting and cutting the poles, but we could not always depend upon native labor. Details of soldiers from different companies were assigned to getting poles, and they did good work. When putting in the line from the coast to the lake country in the interior of the island, we utilized the trees along the trails extensively. Almost half the distance of the 40 miles is through a jungly forest, and trees line the sides of the narrow trail. In the open country, however, bamboo poles of the sort shown in Fig. 1 were used. They are easy to secure, because it is only necessary to cut them the right length, no trimming to speak of being required. Fig. 2 shows the type of native knife used in this work. It is made with a very heavy steel blade, and when kept sharp can be used to advantage. Moro linemen have some odd ways of doing work. We did not use these fellows, except for common labor, unless necessary. Fig. 3 illustrates one of the ways in which a Moro makes a joint; he laboriously hooks the ends of the wires and places them in the position shown and then binds them together with finer wire. Another joint which I saw employed is represented in Fig. 4. The ends of the wires are butted, and the butts form a shoulder around which another piece of wire is linked.

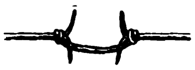


FIG. 4.

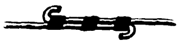


FIG. 3.

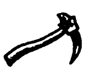


FIG. 8.

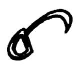


FIG. 9.

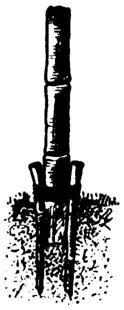


FIG. 10.

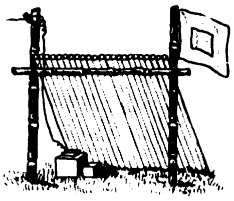


FIG. 6.

I found the native packers to be an interesting lot of men. Two men are capable of carrying about eighty pounds hung on a pole, which rests on the shoulders of the two men. Their method of carrying a coil of wire is shown in Fig. 5; the pole is of bamboo, of course. The natives trot along the hard trails with these loads and seem never to tire; they average about eight miles in the morning and five in the late afternoon.

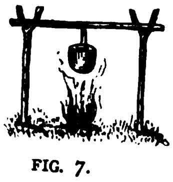


FIG. 7.

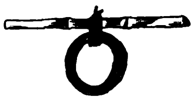


FIG. 5.

Since the establishment of peace around the lakes, which followed the taking of Fort Pandapatan, in the battle of Bayan, a wagon road has been opened, but this is not entirely clear for army wagons; six and eight mules are needed. The road will not aid the lineman materially, because the first move in entering a new country is to get the line in ahead of the troops. The wagons bring up office supplies later.

The telegraph operator with the military expedition must rough it like the rest. For two or three weeks I had a "shelter half," and by doubling up with another man we made a shelter tent. But these tents are too short, and our feet were out; rains were very heavy; we had no cots, only the bare ground and a blanket. I was in the battle of Bayan, and gave my shelter half to a wounded man. After that I used a bamboo and nipa shelter put up on bamboo poles and a cross piece, as shown in Fig. 6; I had the instruments under this "protecting" shelter. The natives would put up a shack like this for me for a dollar. The officers of the troops and the officers of the signal and engineering corps do all they can for one, but when they themselves are using the ground for a bed and making a meal by punching a hole in a tomato can and drinking the contents while nibbling hardtack, you cannot expect much. About half the time we cannot cook because of heavy rains. Fig. 7 shows our cooking rig; we cook coffee in the coffee cups, and they are very black.

Owing to the lack of linemen the telegraphers are frequently obliged to go out to repair damages to the line by the foe. On one trip I found a mile of wire taken out and cut in short pieces, which were bundled up.

Our government is liberal in supplying tools, and all kinds of construction tools are available; but you will find the native workman using devices of his own. Fig. 8 is the native pick and Fig. 9 is a hook-shaped form of native knife. Fig. 10 shows one of the odd ways the natives have of putting in poles for you if you do not watch them. They sink the pole a little way, being too lazy to dig deeply, and then brace the pole with wedges driven in as shown. The parts are bound with native hemp rope. One must watch the natives every moment. This field service is hard, but I would not have missed it for a year's pay.

Lessons in Practical Electricity

ELECTRICAL MEASUREMENTS AND THE WHEATSTONE BRIDGE.

For measuring the resistance of an electrical conductor, an instrument called a "Wheatstone bridge" is frequently used. It consists of a combination of a galvanometer and resistance coils. The galvanometer, Fig. 1, has a coil of fine wire encircling a pivoted hard steel bar magnet, like the needle of a compass. It is similar to the magnetic-needle voltmeter described in a previous Lesson, the essential difference between the two being that the voltmeter needle is made of soft iron. Sometimes the galvanometer needle is held at zero by an outside magnet, like the voltmeter needle, but ordinarily it is allowed to point north and south like the needle of a compass, and the case is twisted around until the zero mark of the scale is under the pointer. Usually the scale is graduated in degrees of a circle.

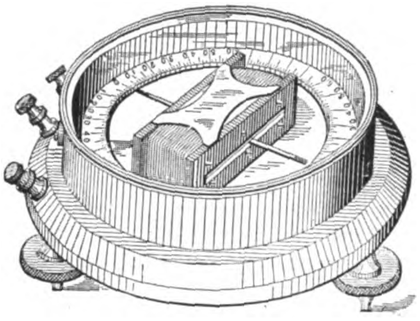


FIG. 1.—GALVANOMETER.

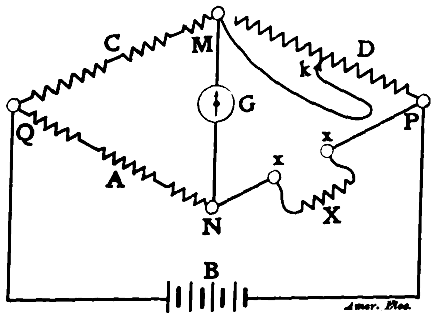


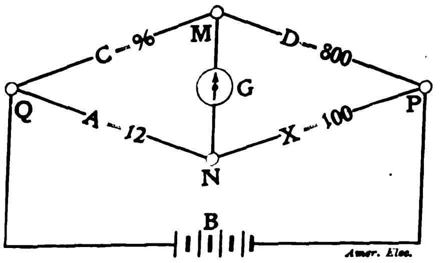
FIG. 2.—WHEATSTONE BRIDGE.

The arrangement of the "bridge" is shown diagrammatically in Fig. 2, in which *A* and *C* are coils of known resistance, *B* is a battery, *G* a galvanometer, *D* a set of resistance coils, which can be cut in or out by means of a movable contact, *k*; *x*, *x* are binding posts to which the object, *X*, to be tested is connected. When the ratio of the resistance of the test object to that of *D* is the same as the resistance of *A* to that of *C*, there will be no current passing through the galvanometer, and consequently the needle will remain at zero. In using the apparatus, the resistance, *D*, is adjusted until the needle of the galvanometer remains at zero. The resistances may be arranged in the form of a proportion, thus:

$$X:D::A:C,$$

from which

$$X=\frac{AD}{C}$$



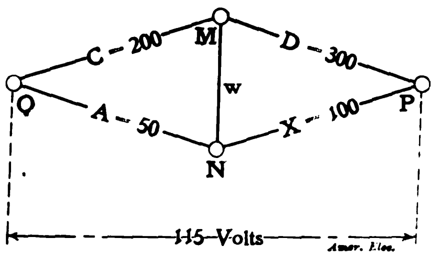


FIG. 3.—MEASURING RESISTANCE BY MEANS OF WHEATSTONE BRIDGE.—FIG. 4.

The reason that the galvanometer indicates zero when $X:D::A:C$ is because there is no difference of potential between M and N. This follows directly from Ohm's law, and is easily understood by taking numerical values for the resistances.

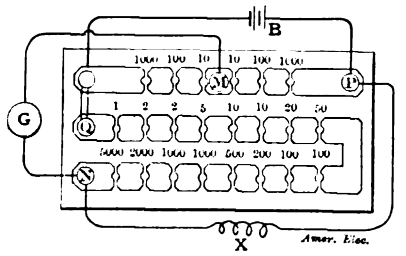


FIG. 5.—PLAN VIEW OF WHEATSTONE BRIDGE.

Suppose the values of the resistances are as given in Fig. 3. Then $X:D::A:C$, each ratio being 1 : 8. Suppose that the total current from Q to P is 0.09 ampere, the current in A and X will be 0.08 ampere, and that in C and D 0.01 ampere. The drop in A from Q to N is $0.08 \times 12 = 0.96$ volt, and that in C from Q to M is $0.01 \times 96 = 0.96$ volt; so that there is no difference of potential between M and N, and, consequently, no tendency for current to flow through the galvanometer. When this condition of things exists the bridge is said to be "balanced."

If the balance is disturbed, current will flow from one side to the other through the galvanometer. Suppose that the resistances are as indicated in Fig. 4, and for the sake of clearness the galvanometer is replaced by a wire, *w*, of negligible resistance. The bridge is out of balance because the ratio of A to C is 1 to 4, while that of X to D is 1 to 3. The combined resistance of A and C is

$$\frac{1}{\frac{1}{50}+\frac{1}{200}} = 40 \text{ ohms},$$

and that of X and D

$$\frac{1}{\frac{1}{100}+\frac{1}{300}} = 75 \text{ ohms}.$$

The total resistance from Q to P is $40 + 75 = 115$ ohms, and as the difference of potential between these points is 115 volts, the total current from Q to P will be 1 ampere. The current will divide at A, one part flowing through C to M and the other part through A to N; according to the law of divided circuits, the relative magnitudes of the currents in the two branches of the circuit will be inversely proportional to the respective resistances. Thus, since the resistance of C is four times that of A, the current in C will be one-fourth of that in A; so that A will carry $\frac{4}{5}$ ampere and C $\frac{1}{5}$ ampere. In like manner, the resistance of D is three times that of X; so that X will carry $\frac{3}{4}$ ampere and D $\frac{1}{4}$ ampere. In order to have $\frac{4}{5}$ ampere in A and $\frac{3}{4}$ ampere in X, evidently 1-20 ampere must cross over from N to M through the wire *w*. If the wire be taken out and the galvanometer again inserted, the needle will be deflected, indicating the passage of current and showing the unbalanced condition of the bridge.

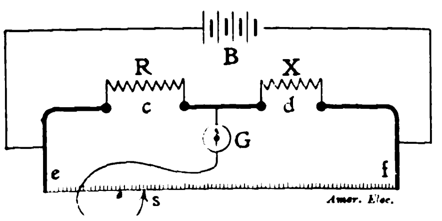


FIG. 6.—SLIDE WIRE BRIDGE.

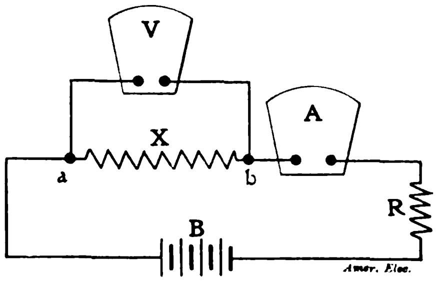


FIG. 7.

In Fig. 5, a plan view of a Wheatstone bridge in commercial form is shown, the parts being lettered to correspond with the other diagrams. With this arrangement, the resistance coils, C, in Fig. 4, are connected to the left-hand part of the upper row of plates; D, to the right-hand part of the same row, and A to the two lower rows; X is the resistance to be measured. If having the 10-ohm and the 100-ohm coils of C short-circuited by plugs, leaving the 1000-ohm coil in circuit, and the 100-ohm and 1000-ohm coils in D short-circuited, leaving the 10-ohm coil in circuit, it is necessary in order to obtain a balance to short-circuit all of the coils in A except one 1000-ohm coil, the 500-ohm coil, the 20-ohm coil and the 5-ohm coil, the resistance of X will be

$$1525 \times \frac{1}{100} = 15.25 \text{ ohms}.$$

A simple form of Wheatstone bridge, called a "slide wire bridge," is shown diagrammatically in Fig. 6. The heavy line represents heavy copper strip of very low resistance, having gaps at *c* and *d*; at each side of each gap is a binding post. Between *e* and *f* is stretched a German-silver wire of uniform cross-section, usually just a meter long between the ends of the strip. A slider, *S*, makes contact at any point along the wire, its position being read upon a scale beside the wire. A battery, *B*, and galvanometer, *G*, complete the outfit. To make a measurement, connect a known resistance, *R*, across the gap *c* and the unknown resistance, *X*, across *d*. Press the slider down upon the wire at one point after another until one is found where the galvanometer needle remains undeflected; that is, where touching and removing the slider, *S*, will not cause the needle of the galvanometer to move. Let l_1 represent the scale length, $e - s$ and l_2 the length $s - f$; then by the bridge principle already explained.

$X:R::$ resistance of l_2 : resistance of l_1.

Since the wire is of uniform cross-section throughout, the resistances of the two parts of the wire are proportional to their respective lengths. Hence,

$$X:R::l_2:l_1,$$

from which

$$X = \frac{l_2}{l_1} R.$$

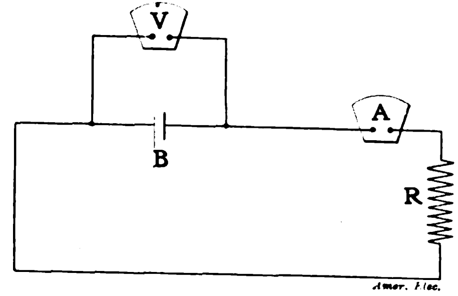


FIG. 8.

If a bridge is to be used for making tests where there are heavy pieces of iron, such as dynamo magnets, which would disturb a sensitive galvanometer, a telephone receiver is substituted for the galvanometer. The receiver is connected and disconnected by means of a key, and as long as the bridge is out of balance a click is heard in the receiver when the key is opened and closed; but when a balance is obtained no click is heard, and the calculation for resistance is made precisely as before.

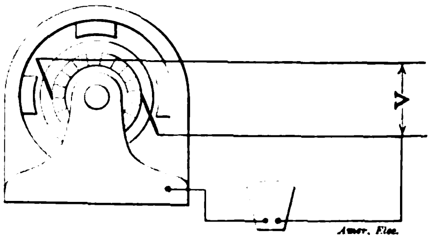


FIG. 9.

Resistance can be conveniently measured in many cases by means of a voltmeter and an ammeter. A diagram of the arrangement of the instruments for this purpose is given in Fig. 7. A voltmeter, *V*, has its terminals connected to the ends, *a* and *b*, of the unknown resistance *X*; an ammeter *A* is connected in series with *X* and a source of current *B* (which may be a battery or a dynamo), and an adjustable resistance, *R*, which is varied until enough current passes through the circuit to give good readings of *V* and *A*, care being taken, however, that it is not excessive. If the "drop" through *X* indicated by *V* be represented by *v* and the current (indicated by *A*) by *i*, the relation between these two and the resistance, *r*, of *X* is by Ohm's law

$$v = i\ r,$$

from which

$$r = \frac{v}{i}$$

Suppose, for example, that for a field-magnet coil $i = 0.4$ ampere and $v = 0.7$ volt, then

$$r = \frac{0.7}{0.4} = 1.75 \text{ ohms.}$$

In order to determine the resistance, b, of a battery, B, under working conditions, a circuit including the battery, an ammeter, A, and a suitable resistance, R, is arranged as shown in Fig. 8. The resistance, R, must be such as to make the output of the battery just what it would be in service under the conditions of the test. The voltmeter, V, is connected across the battery terminals, as shown. The reading, E, of the voltmeter on open circuit gives the e.m.f. of the battery when no current is flowing. If the circuit is now closed and simultaneous readings of the voltmeter and ammeter are taken, the reading, e, of the voltmeter gives the potential difference between the battery terminals when the current, i, indicated by the ammeter is flowing. The drop through the battery is $E - e$, and by Ohm's law the resistance is

$$b = \frac{E - e}{i}$$

It should be remembered that this is the resistance at *the rate of output employed in the test;* at another rate it might be different.

In order to measure the insulation resistance of a dynamo, first measure the volts, V, Fig. 9, across the terminals of the machine; then remove one voltmeter lead and with it grounded on the frame of the machine, take another reading, v; if the resistance of the voltmeter is r, the insulation resistance, R, of the dynamo is

$$R = \left[\frac{V}{v} - 1\right] r.$$

The method of deriving the formula just given is as follows: The current, I, flowing through the circuit, which includes the voltmeter, ground and armature, is, since the resistance of the armature is negligible, compared with that of the rest of the circuit,

$$I = \frac{V}{R + r}$$

With this current the voltmeter indicates the drop in its own windings, which is

$$v = I r;$$

from which $I = v \div r$.

Substituting this value of I in the equation above gives

$$\frac{v}{r} = \frac{V}{R + r}$$

from which

$$R = \left[\frac{V}{v} - 1\right] r.$$

This method may also be used to obtain the insulation resistance of lighting and power circuits.

Letters on Practical Subjects

Electrodeposition of Aluminum From Aqueous Solutions.

To the Editor, American Electrician:

I have a problem which has come up in some recent work of mine, for which I wish you would give me an explanation. Professor Richards, in his book on aluminum, devotes almost a chapter to proving that the electrodeposition of aluminum from an aqueous solution is an impossibility; because it involves the decomposition of the water also, and numerous experiments which have failed are cited. Practically the same conclusions are reached in Watt's and Langbein's books on the electrodeposition of metals. All three of these authorities, I believe, quote the results of some experiments of a Professor Gore, which tend to prove the impossibility of this form of plating.

Notwithstanding the statements of these authorities, I have been plating with aluminum for the past three years; at least, the deposit appears to have all the properties of that metal. There is nothing very complicated about the process which I have used. The solution is made by dissolving metallic aluminum in a solution of ordinary copper sulphate, either with or without the aid of heat. A reaction seems to take place between the aluminum and the monohydrated sulphate, according to the equation:

$$(3Cu\,SO_4\,.\,H_2O) + 4Al = Al_4\,(SO_4\,.\,O)_3 + 3Cu + 6H,$$

forming the soluble basic salt,

$Al_4\,(SO_4\,.\,O)_3$, or $Al_2\,(SO_4)_3\,.\,Al_2\,O_3$, and evolving hydrogen. The solution is ready for use when the precipitation of copper is complete, the liquid then being clear and tasting strongly of alum. I have always used the solution cold, though its conductivity would probably be improved by heating.

The deposition is of a dull lead color on the surface, but takes the characteristic color of aluminum under the buffer. If the current is too strong or the cathode too small, the deposit will consist of an impalpable lead-colored powder. During the deposition a gas is evolved at both plates, to which it adheres closely, and from which it must, for the sake of the regularity of the deposit, be removed by jarring the plates or by means of a feather. The deposited metal not only presents the appearance of aluminum, but also possesses its chemical properties, dissolving in caustic soda, lime water (with a white precipitate) and hydrochloric acid, but not in nitric or sulphuric acids. It also dissolves in copper solutions and in solutions of common salt and alum and salt and acetic acid.

On standing unused, the solution deposits white aluminum hydroxide and is apparently changed into the normal sulphate, from which, as well as from the chloride and acetate, the metal will not deposit except as the hydroxide or as a fine gray powder. An e.m.f. of about two volts is required for the process. A part of the metal may be deposited as a powder and part in the compact form at the same time. The enclosed samples are the result of about fifteen minutes' deposit, using three quart Laclede cells and an anode surface of about 1 square inch. The coating is thin, but shows the color of the deposit and of aluminum. A very weak current seems to be necessary, but if the current is too weak for the size of the plates used, the deposit will be rough and crystalline. What I desire to know is, did the authorities mentioned miss this process, or am I wrong in supposing the deposit to be aluminum? The coating takes well on copper and brass and fairly well on iron.

FRANK A. MCDERMOTT.

Washington, D. C.

The reply of Dr. J. W. Richards, to whom the above communication with the enclosed samples was referred, follows:

To the Editor, American Electrician:

The small samples of plated brass and copper appear to be really coated with aluminum, and are quite similar in appearance to some platings which I obtained several years ago when testing some of the proposed methods for depositing aluminum from aqueous solutions, using soluble aluminum anodes. The solution used by Mr. McDermott is slightly different from those which have previously been successfully used to attain the same end.

In my work on "Aluminum," third edition, 1895, page 307, I state that "aluminum cannot, by any methods so far advanced, be deposited from aqueous solution without using a soluble aluminum anode," and further in the following paragraph: "It is certain that very good specimens of aluminum-plated ware have been made and sold, several having been examined and tested by the writer personally. A thin deposit on sheet iron, which has been in my possession over two years, shows no sign of rust or deterioration, and suggests the practicability of thus making a substitute for tin plate of greater durability and which will not rust."

I may add that the sample referred to is still in the metallurgical collection in my laboratory at Lehigh University, that it shows no more signs of rusting now than when the above lines were written, eight years ago, and that it has for ten years borne the label, "Aluminum plating, by electricity, from aqueous solution."

Bethlehem, Pa. JOSEPH W. RICHARDS.

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Arc Lamp Construction.

To the Editor, American Electrician:—

A few timely words may not come amiss which would serve to point out a radical defect in some makes of enclosed arc lamps; and one which, up to the present, I believe, has received no notice from any except those who have been caused trouble by it. Several prominent manufacturers use brass in the construction of the lower carbon holder or its supporting rods. I have frequently noticed that when lamps of such construction have been exposed to outdoor conditions for, say, six to ten months, the brass rods become rotten, and very frequently break completely off, and a close examination will show them to be corroded—or the nature of the metal entirely changed so that it will not stand the bending or hammering that a good piece of metal should. What the nature of this change in the metal is I cannot explain to a certainty. Since brass is a mechanical mixture—an alloy—and not a chemical combination of elements, I have thought this corrosion might be due to electrolytic action between the copper and zinc in its composition caused by the presence of minute quantities of acids in a damp atmosphere in conjunction with the current carried by the metal. Or it may be caused by the alternate heating and cooling of the brass. Disregarding the cause, however, it is sufficient to say that in view of the fact cited, brass is not a fit material to be used in the exposed or heated portions of the arc lamp.

Roy C. Jackson.

Gas City, Ind.

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Static Charge on Safety Valve.

To the Editor, American Electrician:

The letter of Louis T. Andre, published in your October number, recalls to mind a curious and almost similar phenomenon experienced by me sometime ago. While making an examination of some boilers, I laid my rule across the levers of a double open-lever safety valve while I made some memoranda. On lifting it up by the brass joint in the middle, I felt a sharp shock of electricity. I tried it several times, with the same result. Then I placed it in the same position on several similar valves on three other adjoining boilers, but without any effect. I could discern no difference between the valves except that the one electrified was discharging a little steam, which impinged on the levers. This induced me to move the weights on the other valves back until they, too, discharged steam, and then I found that they were also charged with electricity, and also that the heavier the discharge of steam the stronger was the shock. After I had touched the levers a few times I touched the end of the fireman's nose and we both felt a sharp pricking pain at the point of contact. We were standing on the top of the boiler, which was covered with the ordinary porous composition. When the steam was impinging strongly on the levers it was not necessary to come directly in contact with them to feel the electricity, for it could be felt a quarter of an inch off.

James T. Smith.

Brooklyn, N. Y.

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Mr. Petry's Problem in Bell Connections.

To the Editor, American Electrician:—

I send herewith two solutions of Mr. Petry's problem in connections for an extra bell in an annunciator installation, as given in your last issue. The arrangement shown in Fig. 1 is my preference; it consists of adding an ordinary magneto extension bell and condenser on the fourth floor and a magneto generator in the pantry, the latter being equipped with the usual automatic short-circuiting device on the spindle. The operation is practically obvious; as the direct current from the battery cannot pass through the condenser on the fourth floor, the extension bell on that floor is affected only by the generator current, and current from the battery can pass through the annunciator only when the push-button is pressed. Turning the generator handle removes the short-circuit at its terminals, of course, and the alternating current from the machine rings the extension bell through the battery. The annunciator drop may possibly be thrown by the generator; but if it is, this is not a serious disadvantage, because the generator would be located near the annunciator, if I understand the conditions of the problem correctly, and it would be small trouble to reset the drop after signaling with the generator.

The second solution (Fig. 2) is as simple, but is less desirable, in my opinion, because the battery on the fourth floor is not so compact as the condenser in Fig. 1, which would be located in the base of the bell box. In this latter arrangement, the extra bell is of the ordinary vibrating type, the fourth floor push-button is displaced by a double-floor push-button is displaced by a double-contact or two-way push and a similar push is inserted in the individual wire from the fourth floor to the annunciator drop No. 4. Pressing the upstairs push rings the annunciator bell and throws the drop by means of

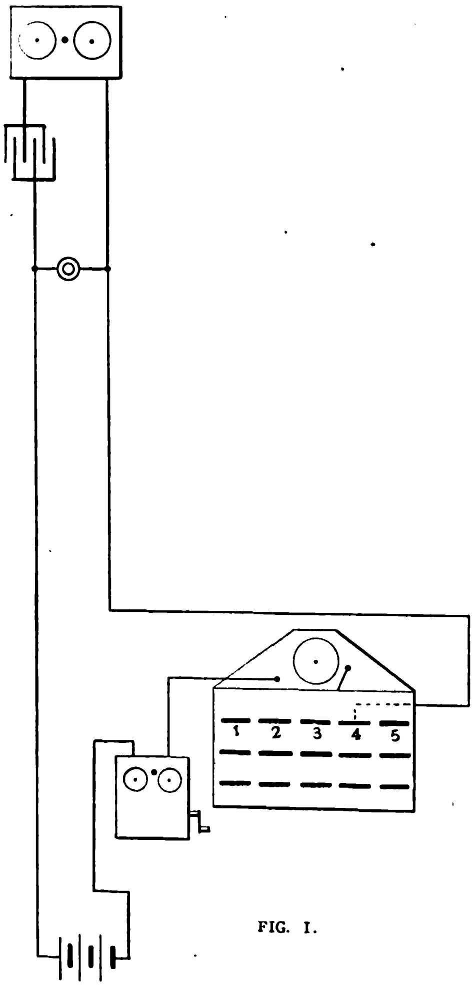

FIG. 1.

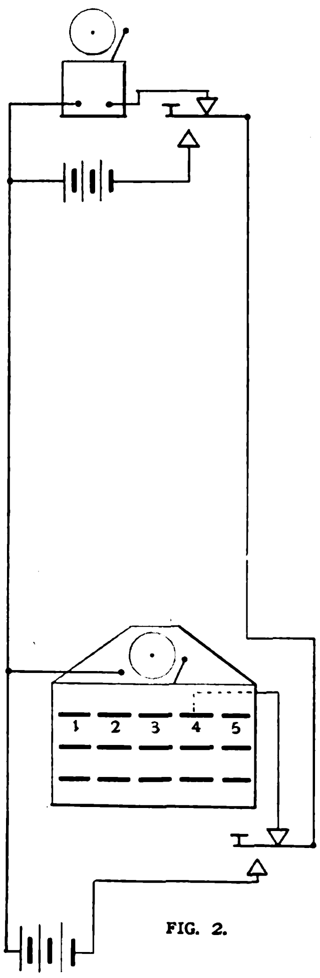

FIG. 2.

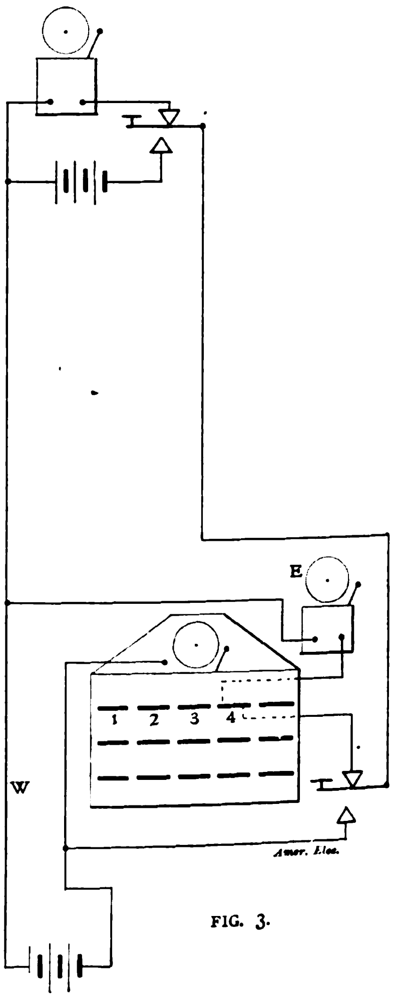

FIG. 3.

the extra battery on the fourth floor; conversely, the bell on the fourth floor is rung by means of the two-point push and the regular annunciator battery downstairs. The batteries are so connected with respect to each other that if both the two-way pushes should be depressed simultaneously, the two batteries would be in opposition and therefore not short-circuited.

A. A. ISBELL.

North Adams, Mass.

[The solution shown by Fig. 2 was also sent in by E. C. Wigham, of New York City, and William Merrill, Wilmington, Del.; W. H. Shadbolt, of Linnell, Minn., and William S. Taussig, of Chicago, submitted a solution identical with this, except that the batteries were not in opposition.—EDITOR.]

To the Editor, American Electrician:—

The accompanying diagram (Fig. 3) is submitted as a solution of the problem in bell wiring by Mr. Petry, which was published in the October number of the AMERICAN ELECTRICIAN. On the fourth floor a return call or two-way push-button is substituted for the ordinary push, and an extra battery is provided in addition to the bell specified in the problem. In the pantry there is another two-way push-button and an extra bell, *E*, outside the annunciator; the terminal of the fourth floor drop, which ordinarily goes to the annunciator bell, is disconnected from that bell and connected to the extra bell, *E;* the other connections are obvious, except, possibly that the wire, *w*, is the common return wire for all the push-buttons of the system except the special one on the fourth floor. Depressing the push-button in the pantry obviously closes a circuit through the fourth floor bell and the basement battery; depressing the button on the fourth floor closes the circuit through the fourth-floor battery, the extra bell, *E*, and drop No. 4 on the annunciator. A little study of the circuits will show why the extra bell is used.

JOHN J. MARSHALL.

San Francisco, Calif.

To the Editor, American Electrician:—

The accompanying diagrams are submitted as practical solutions of Mr. Petry's problem given in this department of your October number. In the first case (Fig. 4), which is perhaps preferable for one reason, mentioned later, the extra bell on the fourth floor is connected to the ordinary push-button wires in series with a battery of the same number of cells as the battery in the basement, and a two-way push-button is inserted in the fourth-floor wire, *d*, near the annunciator, or at whatever point in the pantry it may be desired. The wire, *b*, is the usual common return wire for all the push-buttons in the system, and like terminals of the two batteries are connected to this wire so that the two neutralize each other when the push-buttons are idle. If the button on the fourth floor be pressed, it closes both battery circuits, ringing both bells and throwing the fourth drop in the annunciator. If the push in the pantry be depressed it closes the circuit only through the bell and battery on the fourth floor, leaving the annunciator drop and bell undisturbed. The second solution (Fig. 5) is exactly the same except that an ordinary push-button is used in the pantry, this being bridged across the wires *b* and *d*, so that it produces precisely the same results when pressed as does the button on the fourth floor. The objection to this latter arrangement is that when the fourth floor is signaled from the pantry, the fourth drop in the annunciator is thrown and must, therefore, be reset; if the button were located some distance from the annunciator, this resetting would be neglected most of the time, and produce confusion when a call came in later from another floor.

Brooklyn, N. Y. GEO. W. MALCOLM.

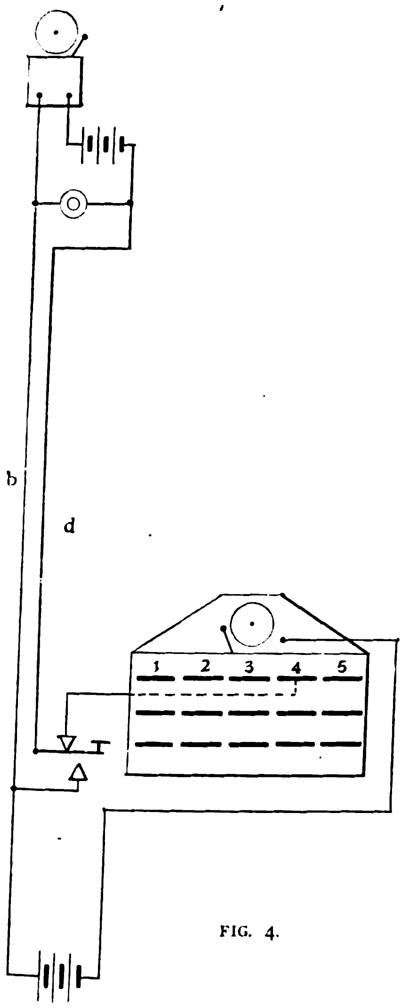

FIG. 4.

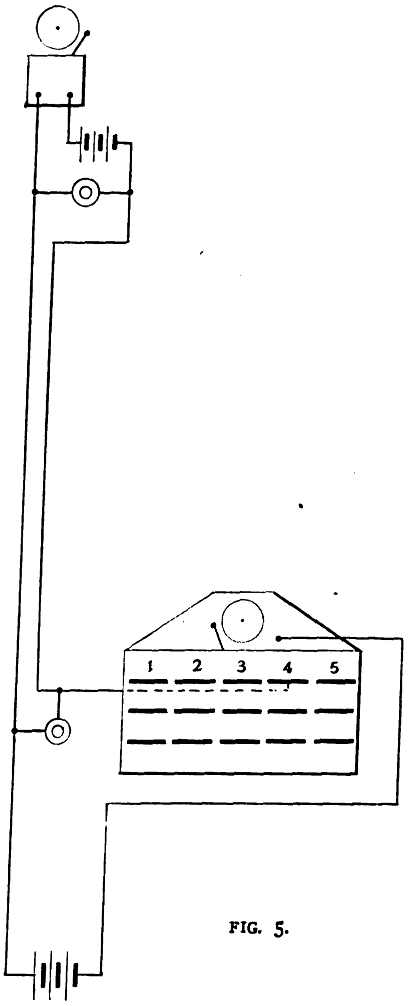

FIG. 5.

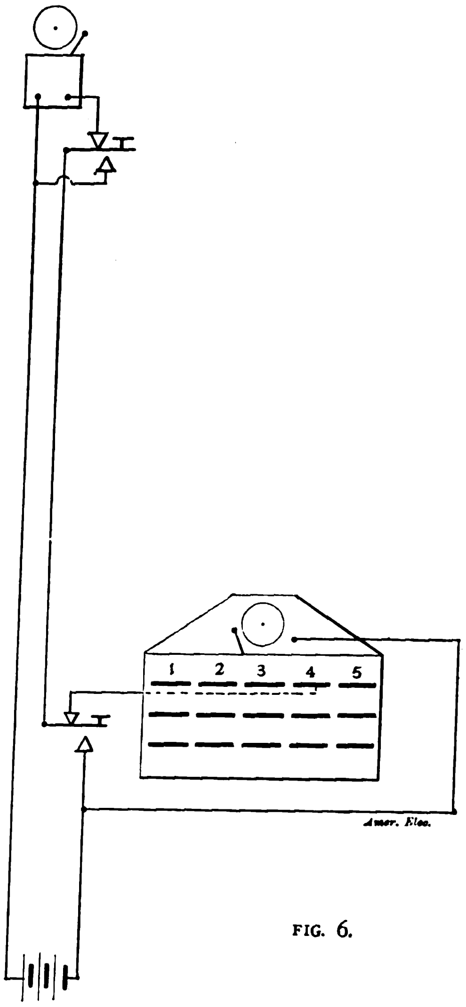

FIG. 6.

[The solution shown by Fig. 5 was also sent in by Lewis M. McBride, of Denver, Colo.—EDITOR.]

Fig. 6 shows a method of connection which was sent in by several readers, and is reproduced only for the purpose of pointing out its defect. With this arrangement, the battery, annunciator bell and drop and the fourth floor bell are normally connected in series; consequently, the fourth drop on the annunciator would remain constantly thrown and the annunciator bell and fourth floor bell would flutter continuously in a vain attempt to ring simultaneously. If the two vibrators would work precisely in unison, the bells would ring constantly, but this condition would not be obtained except by the merest accident.

Queries and Answers

IMPORTANT.—No attention will be given to any inquiry which does not give the full name and address of the inquirer.

How can a set of storage batteries requiring 10 amperes be charged from a 500-volt circuit? It is impractical to use lamps. J. L. G.

Connect up the batteries in series with resistance wire of a size that will stand 10 amperes continuously and of such length that its resistance (in ohms, of course) will be equal to one-tenth of the difference between the voltage of the battery and the voltage of the charging circuit.

What changes will be necessary to adapt a motor wound for 95 volts to work on 9.5 volts? The field magnets are wound with No. 30 wire. G. G. J.

Rewind the field magnets with No. 20 wire, putting on one-tenth of the number of turns per coil that there are in the present winding. Rewind the armature with wire ten gauge numbers larger than the wire at present on it, using one-tenth the number of turns per coil.

How can the positive and negative leads of a direct-current dynamo be identified? (2) Does it matter in which lead the dynamo ammeter is inserted if the machine is shunt wound? (3) How is a ground detector connected for this type of machine? A. R. B.

By means of a voltmeter of the polarized type, such as the Weston, Whitney and similar instruments. (2) No. (3) Exactly as it would be connected for any other type of machine or circuit.

Does it make any difference in which direction a three-phase generator is driven? (2) Is the squirrel cage form of induction motor patented? (3) Can a 25-cycle three-phase induction motor of 5 horse-power be built with two poles per phase? A. H. A.

No. (2) Yes; the fundamental Tesla patents cover all forms of polyphase induction motor. (3) It is possible, but a four-pole machine would be much more satisfactory.

What is the formula for determining the size of pulley necessary to produce a given speed, the size and speed of the pulley to which the unknown pulley is to be belted being known? T. N. S.

Representing the known pulley diameter by D, its speed by S, the unknown diameter by D' and the speed of the unknown pulley by S', $D' = \frac{DS}{S'}$.

[The above was published last month, but vitiated by a typographical error.—ED.]

What is the composition of boiler scale? (2) What boiler compound is advisable for taking out scale? D. S. I.

Boiler scale consists principally of carbonates and sulphates of lime and magnesium, which are precipitated by the heating of the water and baked into scale by the heat transmitted through the boiler plates of tubes. (2) This depends upon the analysis, and can only be determined by an experienced chemist.

What is the effect of too many turns, and what the effect of too few turns in the shunt winding of a dynamo? (2) What are the effects respectively of too many and too few turns in the series winding of a dynamo? R. L.

An excessive number of turns in the shunt winding entails only a waste of copper; too few turns will cause overheating. (2) Too many series turns will cause the machine to compound, or increase its voltage, to an unnecessary extent as the load increases; too few turns will cause the opposite result.

Can a ½-h.p. direct-current motor, of the bipolar iron-clad type, be operated as a rotary converter, taking current from a 60-cycle single-phase alternating-current circuit, the machine being brought up to speed by external means? (2) If so, how many taps should be brought out from the armature winding to the collector rings? A. M. C.

It would be possible, but not very practical for the reason that the speed of the machine would be 3600 r.p.m. (2) Two collector rings would be necessary, one tap being brought out to each ring; the two taps should be connected in at diametrically opposite points of the armature winding.

Why does the speed of a series motor drop after the machine has been running a short time on a constant load? (2) What is the most efficient method of regulating the speed of a series motor? D. F. C.

Presuming that the machine is operated on a constant potential circuit, the drop in speed may be due to the heating of the field winding, which will increase its resistance and thereby decrease the available e.m.f. at the brushes. (2) By means of a sectional field winding, the sections being either cut in and out of the circuit or grouped in different combinations of series, series-parallel and parallel connections.

Can a transformer be made to change 100 volts alternating current to 5 volts direct current? (2) If not, what would be the best way to effect the transformation? H. S. W.

No; a transformer is essentially an alternating-current piece of apparatus and can only change the voltage or the number of phases without changing the character of the current. (2) If the frequency is not greater than 60 cycles, the best method would be to use a transformer to reduce the voltage and deliver the reduced voltage and increased current to a rotary converter in order to change it to direct current. If the frequency is above 60 cycles, a motor-generator would be preferable, and this could be made both to reduce the voltage and to deliver direct current, without using a transformer.

What is the inductance per mile of a 20-pair telephone cable made up of No. 14 wires, each pair having a capacity of 0.05 microfarads per mile? J. D. H.

The inductance of a telephone cable is negligible, as the two wires of each circuit are very close together. You probably refer to impedance. The formula for impedance under these conditions is:

$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi f C}\right)^2},$$

in which R is the resistance of the circuit, f the frequency or number of complete reversals per second, and C the capacity of the line in farads. In telephone work it is difficult to predetermine the impedance because the frequency varies widely; it is customary, however, to assume an average frequency of about 800 cycles per second.

How can a large magnet be disconnected from an exciting circuit without entailing an inductive discharge? H. R. F.

Connect a closely graduated resistance coil across the exciting circuit; connect one terminal of the magnet coil to one extreme terminal of the resistance wire, say the terminal that is connected to the negative line wire, and the other terminal of the coil to a moving contact arranged to slide over a row of contact buttons similar to those on a rheostat face, the buttons being tapped in to the resistance wire at short intervals. In order to excite the magnet the movable contact will rest on the button connected to the positive terminal of the resistance wire. In order to cut the coil out of circuit, slide the movable contact along the buttons until it reaches the one connected to the negative end of the resistance wire, when the magnet coil will be short-circuited. The switch connecting the resistance wire to the circuit may then be opened.

The field winding of an inductor type alternator overheats. The machine is excited by a six-pole direct-current dynamo and is not overloaded. The field rheostat of the exciter has to be cut entirely out before that machine will pick up; has this anything to do with the heating of the alternator field winding, and if not, what is probably the cause of it? B. L. H.

The sluggishness of the exciter in picking up its field has nothing whatever to do with the temperature of the alternator field winding. The heating may be due to the fact that the field coils have not sufficient radiating surface, or to lack of speed. If the speed of the revolving member is not as high as it was intended to be it is necessary to excite the field abnormally in order to obtain the proper voltage. It is further possible, though not probable, that the heating is due to excessive exciting current rendered necessary by excessive drop in the lines. A combination of these three causes might produce serious overheating, even though any one of the causes alone might not be seriously abnormal.

Will a locomotive burn more coal if it runs a given distance at the rate of 60 miles an hour than if it runs the same distance at 30 miles an hour? W. J. R.

A definite reply is impossible without having more data on which to base the calculation. Generally speaking, a locomotive requires more than twice the quantity of coal per hour, or other unit of time, when running at 60 miles an hour than when running at 30 miles, but as the efficiency of the engine would be higher at the higher speed than at the lower one, and as the rate at which the coal consumption increases with increase in the speed cannot be definitely stated, it is impracticable even to say whether more coal would be burned at the higher speed than at the lower, the distance being the same in both cases. If the increase in efficiency at the higher speed were sufficient to decrease the coal consumption per horse-power developed in the same proportion that the coal per mile-per-hour increases, then the total quantity of coal would be the same in both cases.

BURGER AUTOMATIC GAS ENGINE.

Fig. 1 herewith shows the Burger automatic gas engine which the builders, Woolley Foundry and Machine Works of Anderson, Ind., claim is especially adapted for driving dynamo electric machines. Simplicity and reliability are the special claims made for this engine. The bed is of the box type with two bored bearings. The cylinder is water-jacketed and fitted to the bore of the bed, having a flange by which it is secured to the bed by studs of which two are equal to the expansive force. By this construction, it is claimed, the effects of expansion and contraction are eliminated, and the practice is said to be superior to bolting the cylinder to the top of the bed, which is subject to expansion and contraction, as well as shearing strain on the bolts. The piston is of the trunk pattern, extra long, having a long bearing in the cylinder, preventing the cylinder from wearing more in the centre than at the ends. A box type of connecting rod is used and the bearings are adjusted by a wedge, making it unnecessary to remove the piston to adjust the cross-head bearing. The fly-wheels are heavy and each is turned crowning to allow of belting from either one. The automatic starting device furnished with each engine consists of a steel, brazed air tank, with a system of valves, arranged in such a way that the compression of the engine will pump a sufficient amount of air for starting.

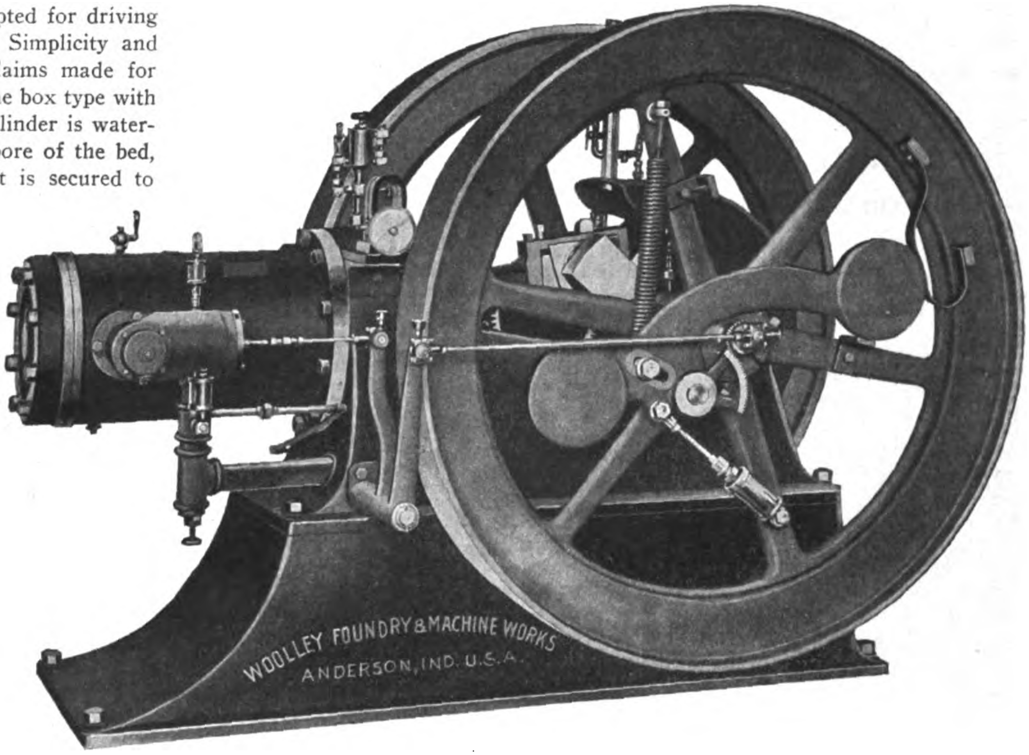

FIG. 1.—BURGER AUTOMATIC GAS ENGINE.

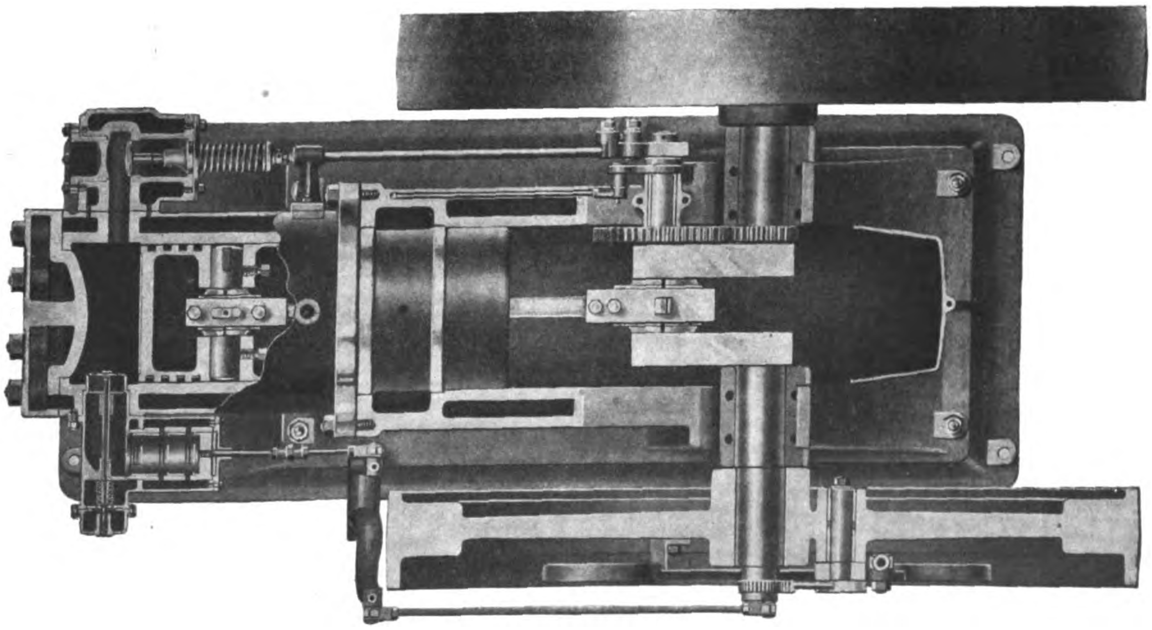

FIG. 2.—SECTIONAL VIEW OF BURGER AUTOMATIC GAS ENGINE.

A Rites governor is used with Burger's improvements, consisting of a pinion rotatable on the end of the crank shaft and carrying a wrist pin to impart motion to the valve. The gear on the governor meshes into the pinion rotating it to change its position to the crank. Referring to Fig. 2 which shows a sectional view of the engine, the governor valve is cylindrical, having ports which cover similar openings in its case. The two ports to the right are air ports. Eight ports are provided for air and two for gas. The third port, or the one to the left is the gas port. The inlet valve protrudes into the cylinder and carries a gas valve on the outer end of its stem. On the suction stroke the inlet valve opens, permitting the gas to pass from the outer chamber to the inner and through the ports in the cylindrical valve into the cylinder. The amount of air and gas which will pass through the ports is governed by the length of time these remain open. If the engine is on one-quarter load the governor will close the ports when the piston has traveled one-fourth its stroke. If on full load the ports will remain open until the piston has made its entire suction stroke. In case the full load should be suddenly thrown off the governor will instantly cut down the port opening to one-sixteenth or one-eighth of the piston travel. The cylindrical valve is, as shown, a cylinder having a bar across one end to attach the valve stem and has circular ports cut around. Reference to Fig. 1 will show that the governor pinion is provided with a wrist pin from which a reciprocating motion is imparted to the valve.

The stroke always remaining the same, in order to get the automatic effect, it is necessary to rotate the pinion to change the position of the wrist pin with relation to the crank. The simple construction of the exhaust valve and its mechanism is clearly shown in Fig. 2. In order to remove the exhaust valve it is only necessary to remove the head in the valve case which is seated on its inner end.

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THE WARREN ROTARY ENGINE.

The accompanying engravings illustrate an extremely interesting type of rotary engine, which is the invention of Mr. E. C. Warren and is manufactured by the Rotary Engine Company, of Philadelphia. As the cross-sectional view, Fig. 2, indicates, the engine consists of a concentric piston wheel and shaft mounted between two abutting rollers, which are in close contact with the periphery of the piston wheel and revolve in a direction opposite to that of the piston. The piston wheel carries a broad flange at each end, and a web in the center, as shown in the perspective view of this member, Fig. 3, and between these flanges and the web are located the driving vanes or blades. The outer edges of these run in close contact with the surrounding casing, as indicated in the cross-section, Fig. 2.

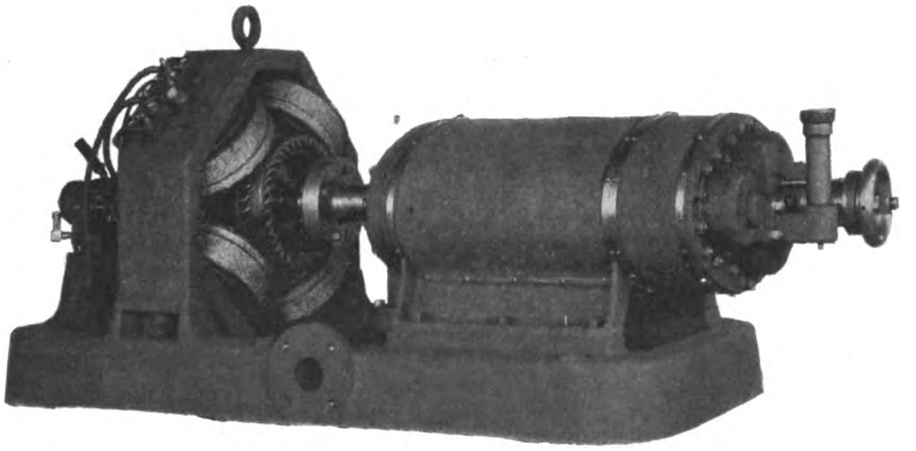

FIG. 1.—WARREN ROTARY ENGINE COUPLED TO DYNAMO.

The main bore of the casing is tapered very slightly from end to end, and the diameter of the piston wheel is measured over the web, flanges and vanes is tapered to correspond. Steam is admitted to the interior of the piston wheel and passes through ports alongside the vanes into the spaces between the drum and the casting, driving the drum around, of course; the slight difference between the diameter at one end of the piston and that at the other causes a moderate end-thrust which tends to force the tapered wheel further into the tapered bore of the casing, thus maintaining a close joint between the flanges, vanes and casing. In order to prevent the wheel from being forced far enough in to jam or cause excessive friction, a small thrust bearing is provided outside the casing, and this is adjustable so that the position of the piston wheel within the casing may be accurately determined.

Instead of using a folding or telescoping piston vane, both of which have been tried in other forms of rotary engine, Mr. Warren provides grooves along the peripheries of the abutment rollers, and the shafts of these rollers are geared to the piston-wheel shaft so that the grooves in the rollers come opposite to the piston vanes when these reach the abutting rollers; in other words, the relation between each piston vane and the slot in one of the rollers is similar to that between the tooth of a gear and the space between two teeth on an intermeshing gear. The abutment rollers are mounted on shafts having bearings in the counterbored end-plates of the abutment chamber, and provision is made in these bearings for the application of elastic pressure toward the main shaft, so that the outward pressure of the steam which tends to force the abutment rollers away from the piston-wheel may be counter-balanced. This pressure is applied on small pistons or diaphragms, to which steam is delivered from the interior of the engine, and the areas of these pistons are such that the pressure on them is just enough to overbalance the outward pressure against the surfaces of the abutment rollers; consequently, this pressure is always overbalanced a trifle, no matter what the pressure of the steam supply may be.

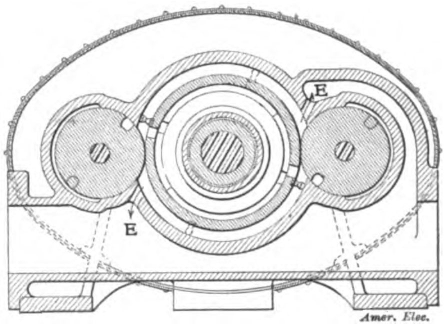

FIG. 2.—CROSS-SECTIONAL VIEW OF ROTARY ENGINE.

Referring again to Fig. 2 the exhaust openings are indicated at *E-E*, from which it will be evident that steam is admitted to the spaces behind the vanes (between the piston drum and the casing) when the piston drum is about in the position shown, the direction of revolution being clockwise. The admission of steam through the ports in the periphery of the piston drum is controlled by drum-shaped valves within the piston drum and mounted on hubs projecting from the heads of the casing. It is stated that it is not necessary to maintain a perfectly tight joint between the valve and the interior surface of the piston drum, because leakage past the valve merely results in raising the expansion line in the working space and adding a slight superheat during the latter stages of expansion. The valve is, therefore, machined merely for a close running fit. In the simple form of engine shown, the point of cut-off is fixed and speed regulation is accomplished by means of throttling.

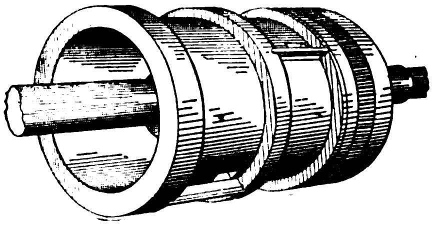

FIG. 3.—PISTON WHEEL.

It is important to note that the respective diameters of the piston drum and the abutment rollers do not coincide exactly with the pitch diameters of the gears through which the three shafts are connected together; consequently, there is a difference between the surface speed of the piston drum and that of the abutment rollers, which amounts to about 600 feet per minute under normal conditions. This produces a sliding contact between the periphery of the drum and the abutment rollers, which is said to cause the three surfaces to wear away in harmony with the advancement of the abutment rollers toward the piston drum, due to the normal wear upon the journals of the rollers. The seats in the casing against which the peripheries of the abutment rollers rub are also worn away, but at a very slow rate. It will be evident from the illustrations that the piston drum is inherently balanced; the abutment rollers are balanced by means of holes drilled in the sides opposite the longitudinal slots.

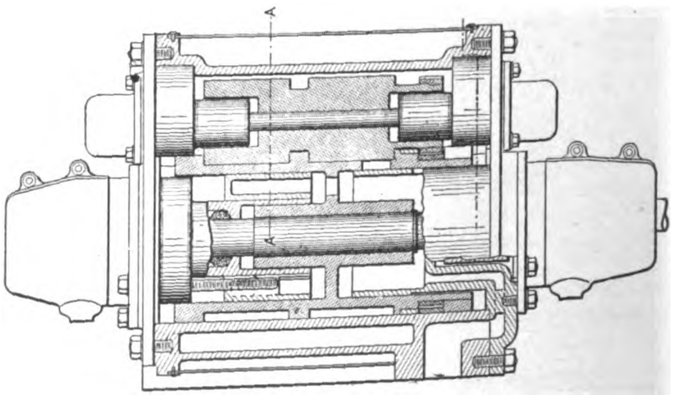

FIG. 4.—LONGITUDINAL SECTIONAL PLAN OF ROTARY ENGINE.

The engine shown in perspective by Fig. 1 is of the type just described and illustrated by the detailed views.

New Apparatus and Appliances

THE MARTIN GRATE-BAR.

The Martin grate-bar, made by the Martin Grate Company, of Chicago, is the result of the application of good engineering and common sense to the design of a rocking grate-bar. Fig. 1 shows a single bar, and gives a good idea of the details of construction. The top of the bar, upon which the fire rests, is very heavy and has no long fingers to become melted or bent. Only a small portion of the metal in the grate-bar is in contact with the fire, and consequently there is a good opportunity for the heavier portion of the bar to conduct the heat away rapidly enough so that it will not be injured. At a distance of about one-fifth the length of the bar from each end is a slot, which allows the top to expand and contract without bending the whole bar; one of these slots is indicated by the hand in Fig. 1. Each bar rocks on a narrow edge, as shown in section in Fig. 1, and is rocked by means of a horizontal link-bar extending across all the grate-bars of one section and to which each bar is pivotally connected by means of a lug projecting downward from the bottom edge of the bar. The heavy bottom part of the grate-bar is 5½ inches below the fire line, and there is free air circulation through the whole bar. In shaking the grate the openings between adjacent bars are not enlarged, and consequently there is no opportunity for clinkers to catch between the bars and prevent them from rocking. It is evident that the bars cannot be left in a position to project up into the fuel, as all the bars tilt together in the same direction. The weight of the grate is about 80 pounds to the square foot. Any kind of coal can be burned on it, but it is especially adapted to cheap soft coal slack and screenings. The size of the openings can be changed to suit fine or coarse grades of fuel; this can be done in about 30 minutes on a set of grates by changing the location of the bars. Over 50 per cent of air space is always maintained, whatever the spacing. Fig. 2 shows a complete furnace equipment of Martin grate-bars, the view being taken from the side of the furnace; the shaking lever is at the front, easy of access without obstructing anything.

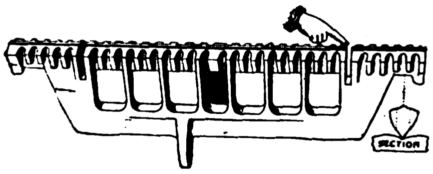

FIG. 1.—MARTIN GRATE-BAR.

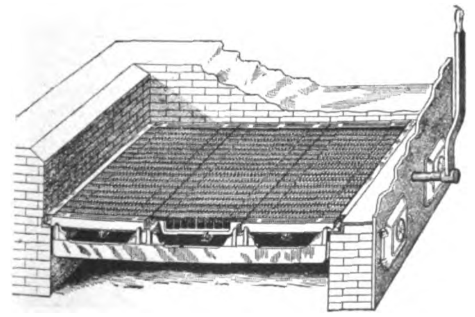

FIG. 2.—FURNACE EQUIPPED WITH MARTIN GRATE-BARS.

BABY NERNST LAMP FOR DIRECT AND ALTERNATING-CURRENT CIRCUITS.

A persistent call for a Nernst lamp smaller in size and illuminating power than any that has yet been presented has led the manufacturers to develop a 25-c.p. lamp consuming 44 and 55 watts, and adapted for either direct or alternating-current circuits. The lamp complete consists of three parts—the lamp body, the holder and the globe. The lamp bodies of the alternating-current and direct-current lamps of the 220-volt type are exactly the same; likewise the bodies of the alternating-current and direct-current lamps of the 110-volt type. The only difference between the alternating-current and direct-current lamps is in the glower, it being understood, of course, that the lamp bodies of the 110-volt type contain a different cut-out and ballast than that used in the body of the 220-volt type. The external appearance and mechanical arrangement of these lamps are substantially the same. They are fitted with a standard Edison base, as shown in Fig. 4, and the housing is of oxidized copper or brush brass finish. The globe is a standard three-inch ball, and is supplied in clear, sand-blasted, alabaster, or opal glass, securely held in place by means of three thumb screws in the petticoat of the housing. Although the manufacturers have been preparing for the manufacture of direct-current lamps for some time, the present lamp is the first direct-current Nernst lamp to be placed upon the market. As is well known, electrolytic action with direct-current in the Nernst lamp is quite marked, resulting in a black deposit on the negative end of the glower, which extends gradually toward the positive terminal. As the deposit increases, the voltage of the glower changes somewhat and the candle-power and efficiency drop, owing to the poor light-emitting properties of the blackened portion of the glower. In the alternating-current lamp no appreciable electrolytic action takes place, so that the connections to the glower are fastened to each end. The glower of the direct-current lamp differs in that it has an elongation, and the connections are made at one end and about one-third of the distance in from the other end, ostensibly for the purpose of causing the electrolytic action to be ineffective during the life of the glower, the wire being wound around the elongation from the end of the glower to the point of connection. The current for the direct-current lamps must also be passed through the glowers in a given direction, and in order to accomplish this the sockets must be so wired that the center of the socket is the positive terminal and the screw shell the negative terminal. To aid in determining whether the sockets are properly wired a polarity indicator is sent with every holder. This is a slip of paper which, when placed in the socket, so as to touch both points of contact, turns red at the point where it touches the negative side of the line. If this happens to be the shell, the socket is properly wired. The 110-volt type of lamp, whether using alternating or direct current, is designed to take 0.4 ampere at the rated voltage, and the 220-volt type 0.25 ampere at the rated voltage, the watt consumption of the 110-volt lamp being 44, and that of the 220-volt lamp 55. The lamps are supplied with either horizontal or vertical glowers, the same lamp body serving for both. Fig. 4 shows the lamp body with the globe and horizontal holder removed. By loosening the bayonet joint near the Edison base, both the brass cap and housing proper may be easily slipped off the lamp. The housing proper carries with it the bottom porcelain, through which the three holder contact clips protrude. The contact clips, together with the ballast and cut-out, are mounted in a compact arrangement on the Edison base porcelain in the top of the lamp. A radical change has been made in the construction of the heater and holder of the lamp, this being designed with the intention of replacing the same with a com-

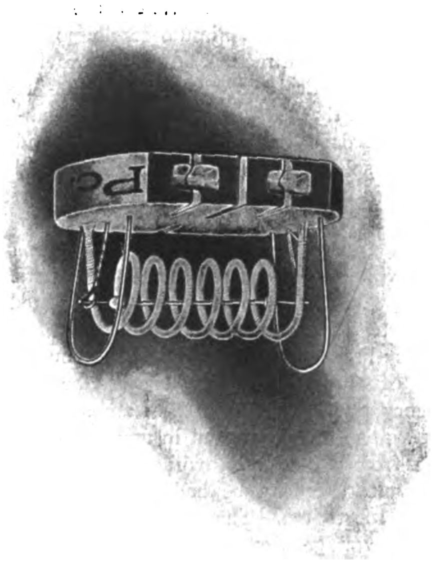

FIG. 3.—RENEWABLE NERNST LAMP GLOWER AND HEATER.

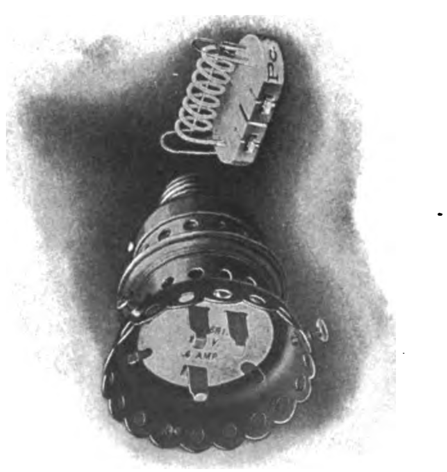

FIG. 4.—DETAILS OF 25-C.P. NERNST LAMP.

plete new holder when the glower or heater fails. The heater consists of a porcelain tube, wound with a fine platinum wire and covered with a white refractory coating. This tube is then wound into a helical form, in the axis of which the glower is fixed. As shown in Figs. 3 and 4, the heater and glower are centrally mounted on the holder porcelain, the terminal wires being fixed in the bottom of three recesses in the sides of the porcelain to form the holder contacts; two of these are on one side of the porcelain and one on the other. Fig. 3 shows a holder provided with a horizontal glower, the maximum candle-power being obtained directly beneath the lamp provided with this style of holder. Where it is desired to obtain the maximum candle-power in a horizontal direction, a holder provided with a vertical glower is obtainable. It is apparent that the labor necessary in making renewals is reduced to a minimum and consists solely in the replacement of the old holder with a new one. The average life of the holders, when run on a circuit regulated within 5 per cent either side of the actual lamp voltage, is guaranteed to be 400 hours. It must be remembered that when operated on alternating-current circuits the frequency has a very marked bearing upon the life of the glower; the higher the frequency the longer the life. Lamps of the 220-volt type may be had in any even voltage from 200 to 240, while those of the 110-volt type may be had in any voltage from 100 to 120. The adjustment for different voltage circuits is all made on the holder and only requires the use of different glowers. The lamp is manufactured by the Nernst Lamp Company, for whom W. M. Sheehan & Co. are New York agents.

DOWNWARD LIGHT INCANDESCENT LAMP.

A new type of incandescent electric lamp has been developed by the Downward Light Electric Company, of New York City. Figs. 5 and 6 show the appearance of the lamp as well as the design of the filament, while the distribution of light from it as compared with other standard lamps on the market, is shown in curves plotted by the Lamp Testing Bureau of New York. (See Fig. 7.) The filament, as will be seen from the illustrations, has been designed with a view to obtaining the maximum intensity of light below the bulb. This, of course, is obtained at the expense of horizontal distribution, but where vertical distribution is desired the lamp will no doubt meet with approval. The curves of Fig. 7 record average conditions. Curve No. 1 is from a double carbon lamp; curve No. 2 is from an oval anchored lamp; curve No. 3 from a double round coil lamp; No. 4, from a flattened double coil lamp, and curve No. 5 from a downward light lamp. In every case the lamps tested were 16-c.p. incandescent lamps. The lamp is manufactured with a tipless bulb and consequently possesses all of the advantages of that type of bulb.

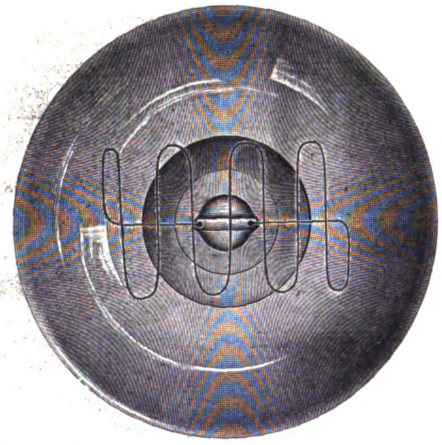

FIG. 5.—DOWNWARD LIGHT INCANDESCENT LAMP.

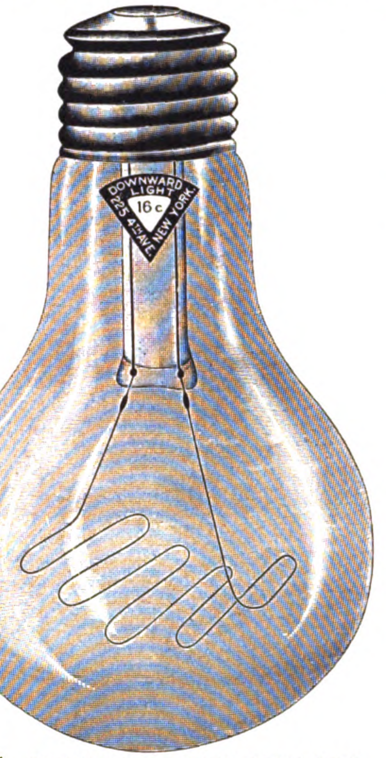

FIG. 6.—DOWNWARD LIGHT INCANDESCENT LAMP.

A NEW FIELD RHEOSTAT.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has brought out a new dynamo field rheostat, the construction of which differs from other apparatus now on the market in that all the current-carrying parts are mounted on an insulating base, the iron portions of the rheostat being simply for the purpose of protecting some of these current-carrying parts, and for giving a certain amount of finish to the rheostat. The rheostat is circular in form, and made up in three sizes, approximately 9, 12 and 15 ins. in diameter, respectively. The construction consists of the circular insulating base above mentioned, which carries all contact parts, etc., and which is attached to the cover by means of three bolts in the 9-in. and 12-in. sizes and four bolts in the 15-in. size. These bolts pass through the cover and through holes in the insulating base, but the cover and bolts do not come into direct contact with the insulating base, as mica is inserted between the surface of the base and the bearing bosses on the cover, and the holes through which the bolts pass are also bushed with mica tubing. This absolutely does away with any chance of grounding. The insulating base itself consists of a disc of Alberene stone of proper dimensions, 1 inch thick in the 9-in. and 12-in. sizes, and 1¼ in. thick in the 15-in. size. An annular trough approximately 5/16 inch deep and about 3½ inches wide, is formed in this stone, its outer edge being as close to the circumference of the bolt as is possible in order to leave an under-cut rim. The contacts and resistances are laid in this trough, the contacts being mechanically secured to the base by means of projections formed on their inner ends and inserted into holes drilled in the central boss of the insulating base to receive them. Downward projections are also provided at the outer

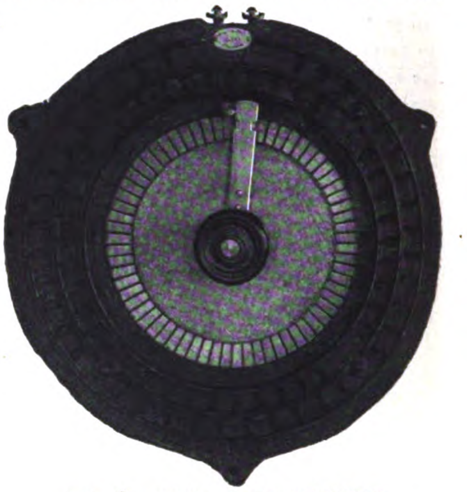

FIG. 8.—15-IN. FIELD RHEOSTAT.

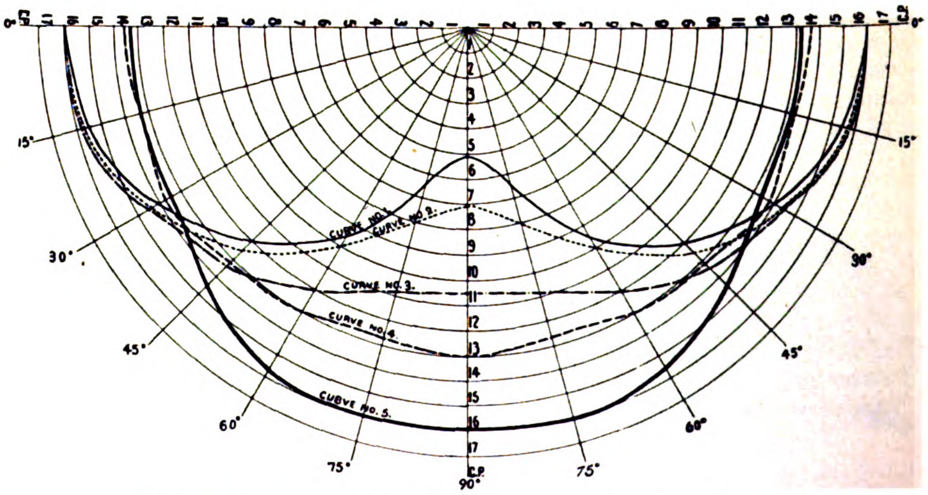

FIG. 7.—CURVES OF LIGHT DISTRIBUTION FROM INCANDESCENT LAMPS.

ends of the contacts, which are forced into similar holes drilled into the base. The mechanical attachment of the contacts to the base thus attained is sufficiently strong to permit of surfacing the contacts by means of a grinding wheel, even without any additional fastening.

The resistance material is of the familiar reflexed wire type laid directly on the insulating base and attached thereto by means of a special cement composition which adheres strongly to the base, this cement also extending through a certain portion of the outer ends of the contact pieces and making them additionally secure. A series of anchor holes for the cement are drilled in the base, and the company states that there has not been reported a single instance of the cement flaking off or being damaged in any way by overload in the rheostats.

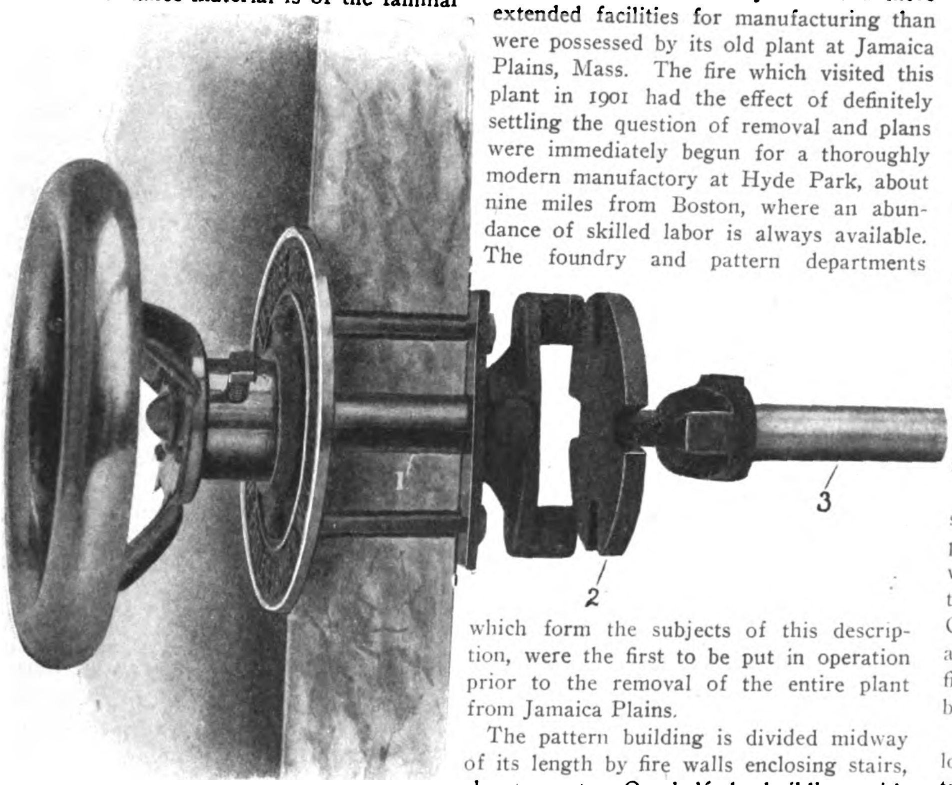

FIG. 9.—METHOD OF INSULATING HAND WHEEL FROM RHEOSTAT SHAFT.

The lever parts of the rheostat are mounted on the central boss formed by cutting the above-mentioned trough, and all are provided with self-adjusting contacts with ample capacity for carrying the largest current which the rheostat conductor is capable of standing. In the front-of-the-board type, a molded composition handle is supplied, which is located at the center of the rheostat, and carries the words, "To raise voltage" with an arrow indicating the direction in which the handle is to be turned in order to accomplish this result. In the rear-of-the-board type, illustrated by Figs. 8 and 9, the shaft passes through the insulating base and terminates in a casting which forms a portion of an insulating coupling. A similar casting is attached to the hand wheel shaft, and the two are connected mechanically by means of a properly shaped fibre plate, as shown clearly by Fig. 9. No bolts or other fastenings are required between the two members of the coupling.

THE NEW FOUNDRY AND PATTERN DEPARTMENTS OF THE STURTEVANT COMPANY.

For several years the B. F. Sturtevant Company has felt the pressure of increased business and the necessity for much more extended facilities for manufacturing than were possessed by its old plant at Jamaica Plains, Mass. The fire which visited this plant in 1901 had the effect of definitely settling the question of removal and plans were immediately begun for a thoroughly modern manufactory at Hyde Park, about nine miles from Boston, where an abundance of skilled labor is always available. The foundry and pattern departments which form the subjects of this description, were the first to be put in operation prior to the removal of the entire plant from Jamaica Plains.

The pattern building is divided midway of its length by fire walls enclosing stairs, elevators, etc. One-half the building, with stories respectively 17 and 15 ft., is devoted to the flask and pattern making rooms, while the other half, provided with intermediate floors, making four in all, is utilized for pattern storage. The flask-shop measuring about 60 ft. by 80 ft., is equipped with band, cross-cut and splitting saws, boring machine and lathe, all driven by a 10-h.p. Sturtevant motor suspended from the ceiling. An industrial railway runs directly into this room from the foundry across a distance of about 40 feet, and together with an over-head transfer truck greatly reduces the cost of handling flasks.

Immediately above, is the pattern shop abundantly lighted on three sides and equipped with a full complement of tools, including one single and two double saw benches, two band saws, a buzz planer and a double surfacer, five lathes, one of which is a 66 in. × 11½ gap lathe, a drill press, a core box machine, numerous wood trimmers, etc. All the power machines are operated by two 10-h.p. Sturtevant motors.

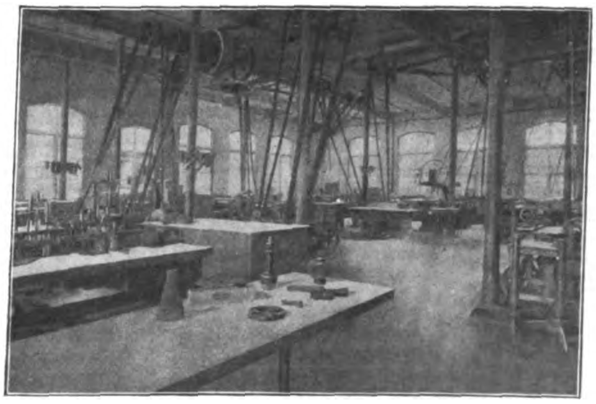

FIG. 1.—PATTERN SHOP.

Around the pipe columns which support the floors of the pattern storage end of the building are clamped the pattern shelving brackets which are adjustable to any height. All patterns are consecutively numbered upon the drawings as made. When delivered to the pattern storage department proper locations are assigned, and records thereof made upon cards, one for each pattern; these cards are filed in the order of the pattern numbers. Four figures with the addition of a letter are in every case sufficient to locate a pattern. A given location, for instance, may be 2125B; that is, it is upon the second floor, as shown by the first numeral, "2," it is in the twelfth row of shelves and the fifth division of that row as shown by the succeeding numerals, "125," and on the B level, the floor being designated A, and the letters B, C, D, etc., indicating the shelves in their order above.

The first floor is of concrete, and is designed for the storage of heavy cast iron patterns. It is served by an industrial railway and a turn-table for making transfer to the elevator for delivery to other floors. Communication between the pattern shop and storage department is direct, while the fire risk is reduced to a minimum by a double system of fire doors.

The foundry consists essentially of two long craneways each 35 ft. wide, with a central section of the same width, and side floors 30 ft. wide. The brass foundry, core room and wash room are located at one end; the charging floor at one side, nearly midway of the length, and the cleaning room at the other end. The craneways are designed for 20-ton electric traveling

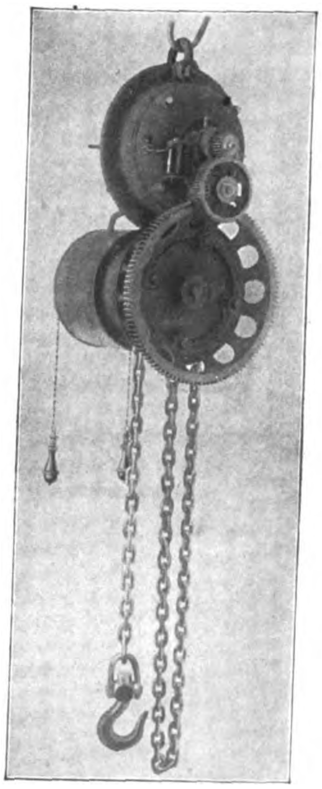

FIG. 2.—ELECTRIC HOIST.

cranes. Those already installed are of the Whiting Foundry Equipment Company's make, and are equipped with Sturtevant motors.

In the centre line of each of the craneways and in the central section between them runs an industrial railway with turntables connecting with the cross aisles which provides for the distribution of metal, etc., to all parts of the building. The floor between the craneways is supplied with a series of 1½-ton small traveling cranes of about 10-ft. span equipped with Sturtevant electric hoists built especially for this work.

An ingenious system of charging has been devised under which the charging cars pass at floor level in front of the bins, are there loaded with the requisite amounts, weighed and passed to the elevator where they are raised to the charging floor. As each car is unloaded it is pushed forward and started down an incline whence it passes back in a direction opposite to that traversed while being loaded on the floor beneath. An automatic apparatus gradually brings it to a standstill while yet upon the incline, and then releases it so that it may, by its own weight, roll along to an elevator which is automatically tripped and descends to the ground floor level. Here it is removed by one of the loading men and the elevator returned to its place above ready to receive another load.

The entire transportation equipment of the plant, including tracks, cars, trucks, etc., was designed and built by the Sturtevant Company. The tracks in the foundry are imbedded in the concrete runways, and all changes of direction are secured by turn-tables, there being no switches in the works, and therefore no radical truck cars, all cars having rigid bases.

The cars are provided with a special type of ball bearings practically devoid of machine work, but with chilled wearing surfaces. The ordinary flat cars as well as the charging cars are built up of structural steel. The geared ladle cars have malleable iron frames and enclosed spur gear mechanism. Similar construction is employed in the case of the transfer cars for geared crane ladles of medium size, while a simple low platform truck is utilized in the case of the largest crane ladles. The dump cars are in the form of inverted cones and so balanced as to be tipped with the utmost ease. The taper of the cone is such that these cars are practically self-dumping.

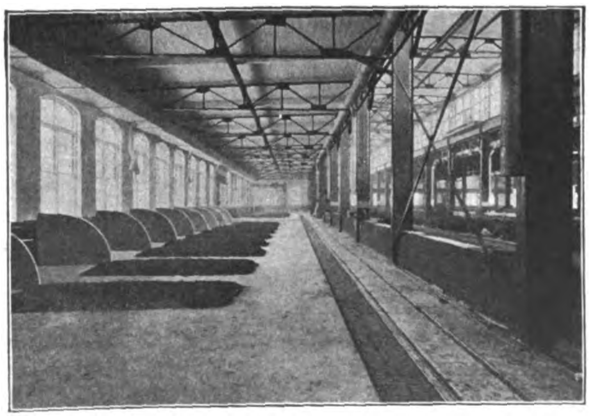

FIG. 3.—BENCH MOULDERS' FLOOR IN FOUNDRY.

The brass foundry, located at one corner of the main building, is provided with four crucible furnaces and a special form of reverbatory furnace designed principally for the melting of babbitt or similar soft metals. An overhead traveler with interlocking transfers on the side floors serves the entire area of the room. Blast for the furnaces is furnished by a No. 3 Sturtevant "Monogram" blower and the entire machinery consisting, in addition, of a sprue cutter, a magnetic separator, a tumbling barrel and emery wheels is driven by a 5-h.p. Sturtevant motor attached to the wall. The entire floor is of concrete, in which is imbedded a section of the industrial railway communicating with the balance of the foundry.

In the center of one end of the foundry is the core room, containing six ovens, three 7 ft. in diameter, of the reel type, and the other three respectively 4, 5 and 7 ft. in width by 8 ft. 10 ins. in length, provided with cars. An overhead traveling crane serves these latter ovens and provides for the transfer of heavy cores to the industrial railway which passes through this room.

At the other end of the foundry is the cleaning room, through which run the longitudinal tracks from each main aisle of the foundry. A five-ton three-motor electric crane of the Whiting Foundry Equipment Company's manufacture equipped with Sturtevant motors serves the principal portion of the floor in this room. The tumbling barrels, six in number, are completely enclosed in housing of steel construction. These, together with a Sly cinder mill and several emery wheels, are driven by a 30-h.p. Sturtevant motor. A temporary air compressor located in one corner and driven by a Sturtevant motor, supplies air at 100 lbs. pressure to chippers, stokers, hoists, etc., employed in connection with this work. The pickle room is adjacent to the cleaning room.

Naturally the entire plant is heated and ventilated by the Sturtevant system. In the case of the pattern building, the apparatus consists of an engine-driven fan and steel pipe heater, placed close to the division wall and arranged to deliver heated air into a vertical flue and thence to the various rooms. The foundry apparatus is located overhead in the end of one of the craneways and arranged to take fresh air from out of doors or return from the building and reheat it. Distribution of air is made through a system of overhead galvanized iron piping, discharging downward to the floor. Both apparatus utilize exhaust steam. A complete underground tunnel system is provided for distribution of steam, electricity, compressed air, etc., and return of condensation.

NEW BOOKS.

The Slide Rule. (Eighth Edition.) By Charles N. Pickworth. New York: D. Van Nostrand Company. Cloth; 104 pages, 5 x 7 ins.; 19 illustrations. Price, $1.00.

This edition of Mr. Pickworth's admirable little book contains a considerable quantity of new material. The recent developments of the slide rule and slide-rule manipulation are treated, the number of practical examples has been very much increased, and sections on special cursors and the solution of algebraic equations have been added. The present edition is also more substantial as to mechanical workmanship. The illustration of the Mannheim rule (Fig. 4), however, remains deplorably inadequate.

The Alternating-Current Transformer. By F. G. Baum. New York: McGraw Publishing Company. Cloth; 195 pages, 5½ ins. x 7½ ins.; 122 illustrations. Price, $1.50.

This is essentially a text-book for students fairly well advanced in mathematics, although it contains sufficient engineering data to make it serviceable as a reference book to any one concerned with transformer design. The author opens with a chapter on "elementary" principles in which he resorts to differential calculus in order to explain that the co-efficient of self-induction of a coil is equal to the product of the linked flux and number of turns divided by the current (in absolute units). This is followed by an explanation of pressure and current components and phase relations, a discussion of regulation, efficiency, testing, design, variants of the ordinary form of transformer, etc. The sequence is natural, and the treatment on the whole is clear, provided the reader has sufficient mathematical and electrical knowledge to follow the author, who manifests an irritating looseness of style capable of causing confusion in the mind of an untrained reader. Thus on the first page: "Power appears(?) in the secondary circuit." On page 49: "*R* is the equivalent(?) resistance of the transformer," and, referring to a graphical diagram, "The length *fg* is called the inductive pressure," and on page 140: "We get a pressure at right angles" to another pressure. To those capable of perceiving the author's meaning in places of this sort, the book should be welcome as a very complete and reliable exposition of the fundamental principles of the transformer and the present state of the art in construction.

OBITUARY.

FRANK V. CLARK, master mechanic of the Varley Duplex Magnet Company, died last month from injuries sustained at the crossing of the East Providence and Consolidated Railroads, near the American Electrical Works. Mr. Clark was only twenty-eight years old at the time of his death.

F. D. OLMSTED, assistant chief manager of the Telluride Power Company and the Power Company of Montana, died on October 4 at Denver, Colo., of tuberculosis and heart trouble, after a short acute illness. Mr. Olmsted was an Ann

Arbor graduate, and prior to his connection with the Telluride Company was with the Edison Electric Illuminating Company, New York. He has done a great deal of highly creditable original work in hydraulics during his connection with the Telluride and Montana Companies, and collaborated with Mr. P. H. Thomas, of the Westinghouse Company, in his work on static strains due to interruption of high-tension transmission circuits. Mr. Olmsted died on his twenty-eighth birthday.

DR. ROBERT H. THURSTON, Dean of Sibley College, Cornell University, died suddenly at his home on October 25, from heart disease, while sitting in his study awaiting the arrival of Mr. Andrew White, formerly president of the university; Dean Huffcut, of the College of Law, and several others who were to be guests at a dinner in honor of his birthday; he was sixty-four years old on the day of his death. Dr. Thurston was born in Providence, R. I., in 1839, and was graduated from Brown University in his twentieth year. He was employed until the beginning of the civil war in the shops operated by his father, who was one of the first builders of steam engines in this country. When the war broke out, he joined the engineering corps of the United States Navy and was twice promoted for gallantry and commendable service during the war; at its close he received his commission as first assistant engineer. After the civil war he was appointed a professor at Annapolis. In 1872 he resigned from the Navy to take the chair of Mechanical Engineering at Stevens Institute, Hoboken. In 1885 he went to Cornell University, where he remained up to the time of his death. Prof. Thurston served on many national and state commissions and was a member of numerous United States and foreign scientific bodies. He was an authoritative writer, several of his books being used as standard text books. Among these may be mentioned: "Friction and Lubrication," "Materials of Engineering," "Stationary Steam Engines," and "A Manual of Steam Boilers." He also made valuable contributions to the technical press, several of which appeared in the AMERICAN ELECTRICIAN.

PERSONAL.

MR. N. J. HIGLEY has resigned the superintendency of the Belvidere (Ill.) Gas & Electric Company, and accepted the managership of the Iowa City Gas Light Company.

MR. C. W. BARTLETT, the Nebraska representative of the Stromberg-Carlson Telephone Manufacturing Company, has removed from Kansas City, Mo., to Lincoln, Neb.

DR. WILLIAM A. COLLEDGE, well known in educational circles as lecturer in English at the University of Chicago, has been appointed Dean of the American School of Correspondence at the Armour Institute of Technology, Chicago.

MR. H. B. HEWITT, formerly representing the Stromberg-Carlson Manufacturing Company, at Keithsburg, Ill., has been appointed Missouri representative, with headquarters at Chillicothe, Mo.

MR. JOHN MUSTARD, formerly with the Wagner Electric Manufacturing Company, has established an office at 1617 Real Estate Trust Building, Philadelphia, and will represent several manufacturers of electrical specialties.

MR. H. H. VREELAND, president of the Interurban Street Railway Company, New York, recently subscribed $1000 as the nucleus of a fund for the establishment of a laboratory for the Department of Railway Engineering at Sibley College, Cornell University.

MR. GEORGE W. COLLES has resigned his position as chief engineer for Marion & Marion, Montreal, in order to engage in mechanical and electrical engineering work on his own account. Mr. Colles has established offices in the Uihlein Building, Milwaukee, Wis.

MR. JOHN W. GODFREY, who has been for the past eleven years chief electrician for the United Electric Light Company, Springfield, Mass., has been appointed chief engineer of the New Milford Power Company, and has accordingly resigned his position at Springfield. Mr. Godfrey enters upon his new duties November 1.

MR. J. C. MURRAY has been appointed traveling representative of the International Telephone Manufacturing Company, Chicago. Mr. Murray has many friends in the telephone field, having been connected for some time with the Kellogg Company and more recently with the Stromberg-Carlson Company.

MR. A. W. HENSHAW has been given charge of the motor department of the Stanley Electric Manufacturing Company, Pittsfield, Mass. Mr. Henshaw is well known in manufacturing circles; prior to his connection with the Stanley Company he was on the staff of the General Electric Company, at Schenectady.

MR. ISAAC McMICHAELS has resigned his position of Northwestern division superintendent of the Western Union Telegraph Company, after forty-seven years of service with that company, in order to accept the position of general manager of the Great Northwestern Telegraph Company, with headquarters at Toronto, Canada. Mr. McMichael will be succeeded by Mr. James Swan, local manager at Helena, Mont.

MR. CHARLES CHURCHILL, managing director of Charles Churchill & Company, Ltd., of England, which is probably the largest concern in Great Britain handling American machinery and labor-saving devices, is in this country on a visit. Mr. Churchill's headquarters for the present are at 23 John Street, the offices of the American Gas Furnace Company. He will be in the United States until about December 1.

MR. W. H. ZIMMERMAN, who for the past two years has occupied a responsible position on the engineering staff of the Arnold Electric Power Station Company, has been appointed general manager of the De Kalb-Sycamore Electric Company, De Kalb, Ill., whose plant was described in the June issue of the AMERICAN ELECTRICIAN. Mr. De Kalb was graduated from the University of Illinois in 1897 with the degree of Mechanical Engineer.

TRADE PUBLICATIONS.

POWER FACTOR INDICATOR. General Electric Company.—Bulletin No. 4338, containing an illustrated description of the G. E. power factor indicator for balanced polyphase systems.

INTERIOR TELEPHONE APPARATUS. Electric Gas Lighting Company, Boston.—Bulletin No. 1, containing an illustrated description of the "Samson" intercommunicating telephone sets and also illustrations and descriptions of the individual pieces of apparatus and parts thereof.

STEAM SPECIALTIES. Wright Mfg. Company, Detroit, Mich.—Catalogue No. 9 describing the line of Wright specialties, which includes safety water columns, of several styles, "Emergency" steam traps, "Victor" low-pressure steam traps, exhaust heads and filterers. The catalogue is of standard size and fully illustrated.

SMALL DIRECT-CURRENT MOTORS. The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3042, superseding Bulletin No. 3028 and containing a well-illustrated description of a line of multipolar direct-current motors ranging from ¼ to 2 horse-power in output.

STEAM POWER PLANTS OF THE PACIFIC COAST. Chas. C. Moore & Co., San Francisco.—A very ornate book containing a large number of half-tone engravings illustrating plants and types of apparatus installed by the publishers, who are "blanket" contractors for complete plants and install the whole plant, in each case, under their immediate supervision.

PORTABLE FORGES AND BLACKSMITH'S TOOLS. Buffalo Forge Company, Buffalo, N. Y.—A very complete catalogue of pocket size, containing illustrations and brief descriptions of the well-known line of Buffalo portable forges for blacksmiths, boiler makers, machinists, tool makers, riveters, jewelers, prospectors, brazers, etc. The catalogue is profusely and excellently illustrated.

THE NERNST LAMP. Nernst Lamp Company, Pittsburg, Penn.—A superbly executed booklet containing an illustrated explanation of the construction and operation of the Nernst lamp in its latest commercial form, together with views of some installations of Nernst lamps which illustrate admirably the effects obtained. A smaller booklet, designated Catalogue No. 3, is also issued; this is devoted to 44 and 55-watt Nernst lamps for 110 and 220-volt circuits, alternating or direct-current.

THE STAR INCANDESCENT LAMP. The Standard Electrical Mfg. Company, Niles, Ohio.—This is the Standard Company's maiden effort in the catalogue line, being Catalogue No. 1, and if the quality of the lamp corresponds relatively to the quality of the catalogue, it has a brilliant future ahead of it, commercially as well as luminously. The book is handsomely executed and in addition to the argument concerning the Star lamp, and illustrations of the various forms manufactured, it contains some sound advice regarding the selection and service of incandescent lamps in general.

SWITCHBOARDS. Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., and Chicago.—This publication is designated Bulletin No. 6 and Bulletin No. 7, but is in reality a very extensive catalogue, handsomely executed and provided with a substantial cover. The contents of Bulletin No. 6 embrace telephone switchboards of the most modern type for all classes of service; in Bulletin No. 7 the individual switchboard parts are illustrated and described separately, the illustrations showing the parts in full detail. There are also circuit diagrams which should prove useful. The bulletins are built up on the loose-leaf plan, each leaf being independent of all the others and the complete mass being held together by substantial brass fasteners.

BUSINESS NEWS.

THE HATCH ACCUMULATOR COMPANY, of Boston, has removed its headquarters from 201 State Street to 283 Franklin Street, that city.

BROWN-CORLISS ENGINE COMPANY, Corliss, Wis., reports among recent sales one to the Lorraine Steel Company of a 30 and 60 x 60 cross compound Corliss engine.

H. P. WHITE COMPANY, Philadelphia, has been appointed Pennsylvania agent for McLeod, Ward & Company, and will carry a stock of Kinsman specialties in Philadelphia so as to make prompt deliveries.

EDUARD SCHENK, Pittsburg, Pa., has been appointed district representative for the sale of Allfree engines, built by The Ironton Engine Company. Mr. Schenk has established offices in the House Building.

THOS. G. GRIER CO., Chicago, has been appointed Western representative for the sale of Kinsman specialties, manufactured by McLeod, Ward & Company, New York. The Grier Company will carry a full stock of these specialties on hand in Chicago.

CHASE-SHAWMUT COMPANY has removed its main office and factory from Boston to Newburyport, Mass., where much greater manufacturing facilities are available than heretofore. The company is represented in Boston by the Stuart-Howland Company, 283 Devonshire Street.

THE SHELBY ELECTRIC COMPANY, Shelby, Ohio, announces that its New York office, which has until recently been in charge of J. C. Wormley, has been placed under the management of M. G. McKennan. The office remains in the old location in the Parker Building, 225 Fourth Avenue.

THE NATIONAL BATTERY FAN COMPANY, Philadelphia, Pa., has brought out a form of battery which is said to operate satisfactorily without a liquid electrolyte and to retain all the advantages of a primary battery while capable of being recharged at nominal cost like an ordinary storage battery.

THE PEERLESS ELECTRIC COMPANY, Warren, Ohio, reports a considerable export trade in fan motors; several shipments have been made during the past month to India and South America. Peerless transformers are also in favor abroad and a number of export orders have been received recently.

STANLEY INSTRUMENT COMPANY, Great Barrington, Mass., recently made a shipment of glass-enclosed switchboard meters having an aggregate measuring capacity of 16,000 kilowatts. These meters are to be used for measuring power delivered by the New Milford Power Company to the local stations at Waterbury, Cheshire and New Britain, Conn.

WESTINGHOUSE MACHINE WORKS reports that The Eaton Cole & Burnham Company is preparing plans for a steam turbine plant to be installed in its factory at Bridgeport, Conn. The works are to be greatly extended and changed over to electric motor drive throughout; a 400-kw. turbine-generator unit will be installed immediately to provide power during the work of making the extensions and changes in the present power house.

THE STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., has established a new sales office at Cincinnati, in charge of O. H. P. Fant and another at St. Louis in charge of F. Johnson. The Cincinnati office is located in the Perin Building and the St. Louis office in the Century Building. The company reports a continuance of good business; among recent sales may be mentioned a 2000-kw. revolving-field alternator for the Memphis Consolidated Gas & Electric Company, Memphis, Tenn.

H. T. PAISTE COMPANY, Philadelphia, reports large sales in its new three-screw fixture socket, which is said to possess the very great advantage of holding together under all sorts of strains, vibrations and mechanical shocks. A shipment was recently made of these sockets to the United States Government Printing Office at Washington, the order being obtained largely on the strength of the feature mentioned; there is considerable vibration of the printing office building, due to the running of the large presses.

THE TRUMBULL ELECTRIC MANUFACTURING COMPANY, Plainville, Conn., reports a very active business in its lines. In fact, the increase in business has made it necessary for the company to enlarge its factory to double its former size and capacity. This company manufactures full lines of knife-blade switches and porcelain goods such as rosettes, weather-proof sockets, etc., and has just brought out a new flush receptacle which fits in all of the standard switch boxes and takes any Edison-base attachment plug.

H. W. JOHNS-MANVILLE COMPANY, New York, reports that the largest orders ever given for roofing were recently placed with that company by the U. S. War Department for roofing to be used on the army buildings in the Philippine Islands. The order covered a total of 14,020 rolls of roofing, weighing over 200 tons and aggregating an area sufficient to cover 65 acres. Prompt delivery was one of the requirements, and it is interesting to note that this huge quantity of material was got out within 40 days, 11,120 of the rolls being completed within 30 days.

THE VILTER MANUFACTURING COMPANY, Milwaukee, Wis., finds no abatement in the demand for high-class refrigerating and ice-making machinery. Among recent contracts may be mentioned the following: Bay City (Tex.) Ice, Light & Power Company, a 15-ton ice plant and a 3-ton refrigerating machine; Dalhart (Tex.) Ice & Electric Company, a 30-ton ice plant; Leetsdale (Pa.) Ice Company, a 20-ton ice plant; Azusa (Cal.) Ice & Cold Storage Company, a 35-ton refrigerating machine; Southern California Ice Company, a 35-ton ice plant; Nelson, Morris & Co., Philadelphia, a 10-ton refrigerating machine. The Vilter Company also reports a continuance of good business in its well-known Corliss engines.

THE NATIONAL STEEL FOUNDRY COMPANY, recently organized by prominent local capitalists in New Haven, Conn., has joined interests with the National Steel & Wire Company, of that city. The Foundry Company recently purchased part of the 50-acre site owned by the National Wire Corporation, which is a subsidiary company of the National Steel & Wire Company, and is erecting thereon an extensive plant which will have an initial capacity of 35 tons of finished product per day. The National Steel Foundry Company was originally organized for the purpose of supplying the trade of New England and New York with steel castings, but the union of interests with the National Steel & Wire Company has tremendously broadened its field, as the latter company maintains selling departments in most of the principal cities throughout the United States. It is expected that the new foundry will pour the first heat by January 1, 1904.

THE PELTON WATER WHEEL COMPANY, San Francisco, reports that its factory is running night and day to keep up with orders. Among the contracts closed within the past few months are the following, which aggregate 56,000 horse-power: American River Electric Company, Placerville, Cal., head 575 feet, two double units, each of 2500 horse-power capacity; Pike's Peak Hydro-Electric Company, Colorado Springs, head 2200 feet, three wheels, each of 1500 horse-power capacity; Columbia Improvement Company, Tacoma, Wash., head 850 feet, four units each of 7500 horse-power capacity; Vancouver Power Company, head 390 feet, three double units each of 3000 horse-power capacity; Northern California Power Company, head 1150 feet, two double units each of 3000 horse-power capacity; Rock Creek Power and Transmission Company, Baker City, Ore., head 960 feet, two units aggregating 1760 horse-power; Columbus Consolidated Mining Company, 494 feet head, one unit of 660 horse-power capacity.

CROCKER-WHEELER COMPANY, Ampere, N. J., reports the receipt, within the past fortnight, of a number of notable orders, and as these were fairly evenly distributed among the company's larger branch offices, they indicate that the favorable condition of business is not local to any one section. One order, from the Lorain (Ohio) Steel Company, received through the Pittsburg office, covered 41 motors ranging in size from 2½ to 360 horse-power and representing a total of 1423 horse-power. Another large order came from the New Jersey Zinc Company, of Hazard, Pa., through the New York office, for one 125-kw. and two 600-kw. generators, and 37 motors aggregating 401 horse-power. The Philadelphia office placed an order from the Warren Foundry & Machine Company, of Phillipsburg, N. J., for one 200-kw. generator, four 35-h.p. and two 60-h.p. motors, and through the Chicago office the G. H. Hammond Company ordered for its packing plant at the Union Stock Yards in that city one 50-h.p. and one 25-h.p. and two 20-h.p. motors, and an 800-kw. 550-volt engine-type generator. This last machine is a duplicate of one now being built for the St. Louis Exposition, the entire intramural plant for which will be operated by generators supplied by the Crocker-Wheeler Company.

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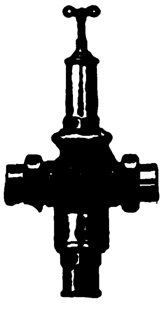
All coupon ticket agents sell tickets via the Chicago, Milwaukee & St. Paul Railway.



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THE MASON REGULATOR CO., Boston, Mass., U. S. A.

American Electrician.

Vol. XV. New York, December, 1903. No. 12.

RECONSTRUCTED AND ENLARGED CENTRAL STATION.

POWER PLANT OF THE MERIDEN ELECTRIC LIGHT COMPANY.

The plant of the Meriden Electric Light Company, at Meriden, Conn., is a good example of the beneficial results which follow a thorough reconstruction. Although of small size, as compared with modern metropolitan stations, the plant has numerous instructive features and its performance rivals that of plants many times larger and illustrates what may be accomplished by the proper design and operation of plants of its size. The company was incorporated in 1888 for serving the city of Meriden with arc and incandescent lights. A power plant was completed and placed in service the same year, furnishing direct-current series-arc and 1000-volt alternating-current incandescent light and power on the independent transformer system. In 1897 the alternating-current incandescent system was changed to a 110-volt, three-wire Edison system, resulting in a reduction in the distribution losses of from 5 to 10 per cent, according to the load. In 1901 the business of the company had assumed such proportions as to necessitate additional power. The old equipment had practically reached the limit of usefulness, and the outlook for a still further increase in business was so encouraging as to warrant the overhauling of the entire system. Subsequent alternations to the system were based upon an engineering investigation of the property with a view to bringing about a more economical condition of generation and sale of electricity.

The power station is situated somewhat south of the approximate geographical center of the city, which also corresponds to the center of service supply. Although the load center is gradually moving northward, the location is favorable to the economical distribution of power. The power house is situated upon the south bank of Harbor Brook and also extends for some distance along the line of the New York, New Haven & Hartford Railroad. The site, therefore, possesses excellent coal and water facilities. By reason of the identity of interests between the city electric lighting and gas plants, a possible site was considered for a new power plant operated in connection with the latter in order that the refuse coke, which at present is carted to the electric plant for part fuel, might be made use of directly. This site had the advantages of cheapness and convenience to railroad tracks, these latter being elevated sufficiently to admit of a coal trestle to the plant, thus avoiding coal elevating apparatus; but by reason of the impossibility of employing labor capable of common service in the two plants and the lengthening of the feeders by one-half mile the old site was retained.

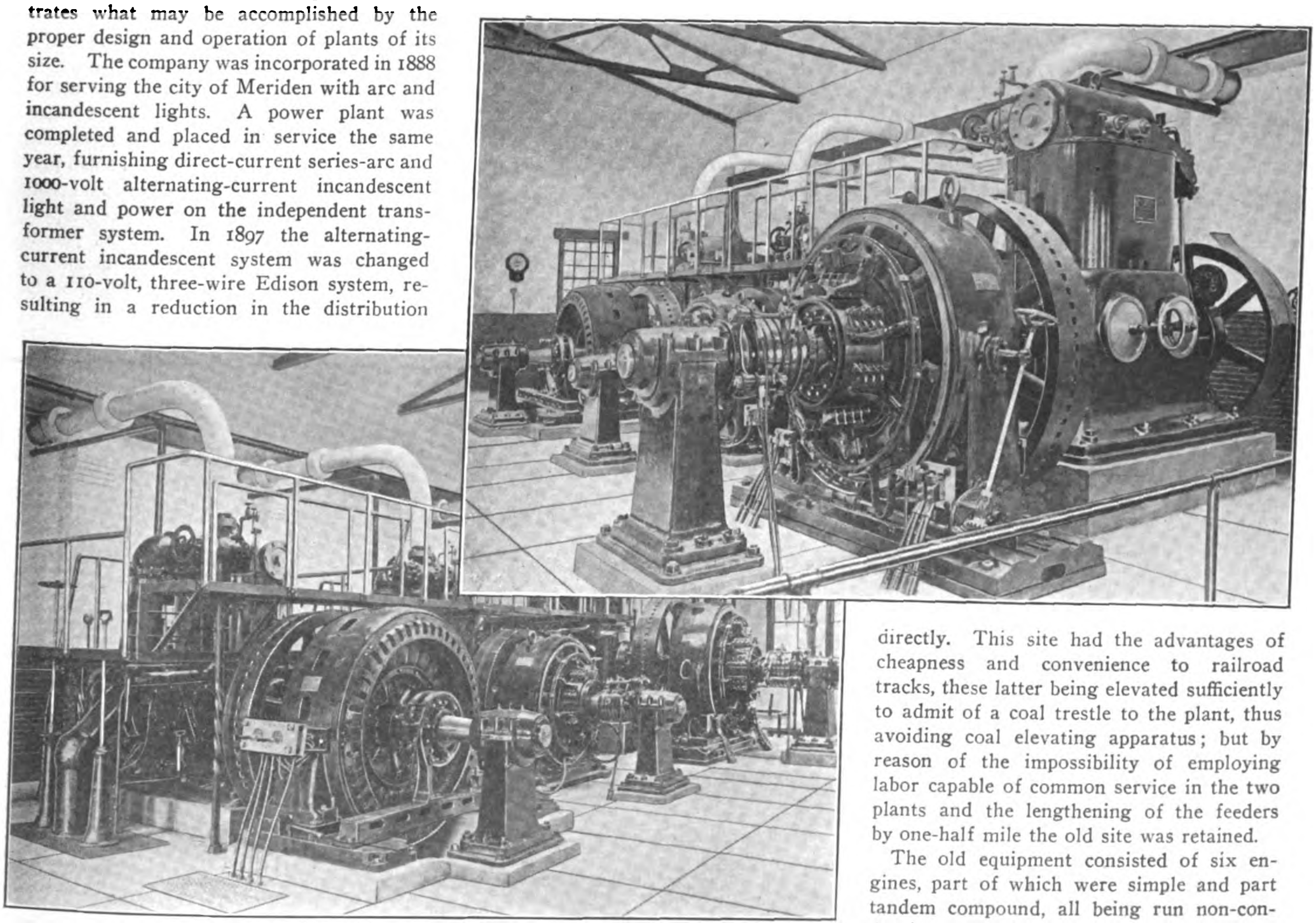


FIG. 1.—VIEW OF GENERATING EQUIPMENT FROM OPPOSITE ENDS.

The old equipment consisted of six engines, part of which were simple and part tandem compound, all being run non-condensing. These were belted to Wood and T. H. arc machines and T. H. and Eddy generators having capacities of 25 to 40 kilowatts. The boiler room contained three 150-h.p. Hazelton boilers and one 150-h.p. horizontal return tubular boiler. A view of the generator room taken prior to the period of reconstruction is shown in Fig. 2.

In the process of reconstruction it was found that in order to accommodate vertical engine type machinery and a traveling crane it would be necessary to obtain additional head room. The old roof was, therefore, cut entirely away close to the walls, and these latter were then extended upward as parapet walls; brick pilasters were also added to support the crane run-way and stiffen the walls for sustaining the roof trusses. The old roof was utilized as a staging and as a protection to the machinery below while the new roof was being constructed. The old wooden floors were supplanted by floors of concrete expanded metal upon structural steel framework. The general thickness was 6 inches, which was increased to 12 inches of concrete between the engine foundations. The latter were also of concrete and were built as fast as the old machinery and floor could be removed. Concrete basement floors were then built with pipe trenches in the rear of the foundations for accommodating the atmospheric exhaust and small auxiliary piping. The building was thus converted into a fire-proof structure and the insurance upon the plant, which was formerly a considerable item, discontinued.

The conversion of the power units was completed at seasons of light load, whereby it became possible to shift sufficient incandescent load upon the other machines and make room for a 225-kw., direct-connected unit. A new steam main was also located beneath the one in service. By transferring the load to the new unit, a second unit of 125-kw. capacity was installed, which completed the incandescent equipment. Both machines were controlled from a new switchboard. By similarly transferring the arc load to an idle machine space was cleared for a direct-connected alternator, which was installed complete with switchboard and regulators. The arc circuits were then successively transferred to the new system during the day and the old series arc lamps of each circuit were replaced by new alternating-current enclosed arcs. During this work concrete floors were constructed, condenser, heaters and new feed pumps installed, and the condenser intake well built.

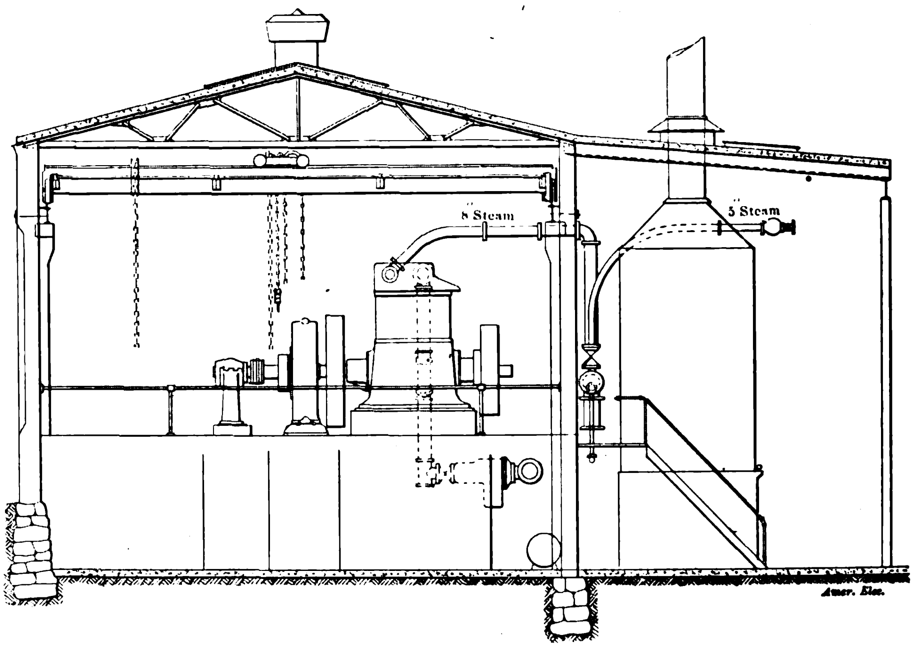


FIG. 3.—SECTIONAL ELEVATION OF POWER HOUSE.

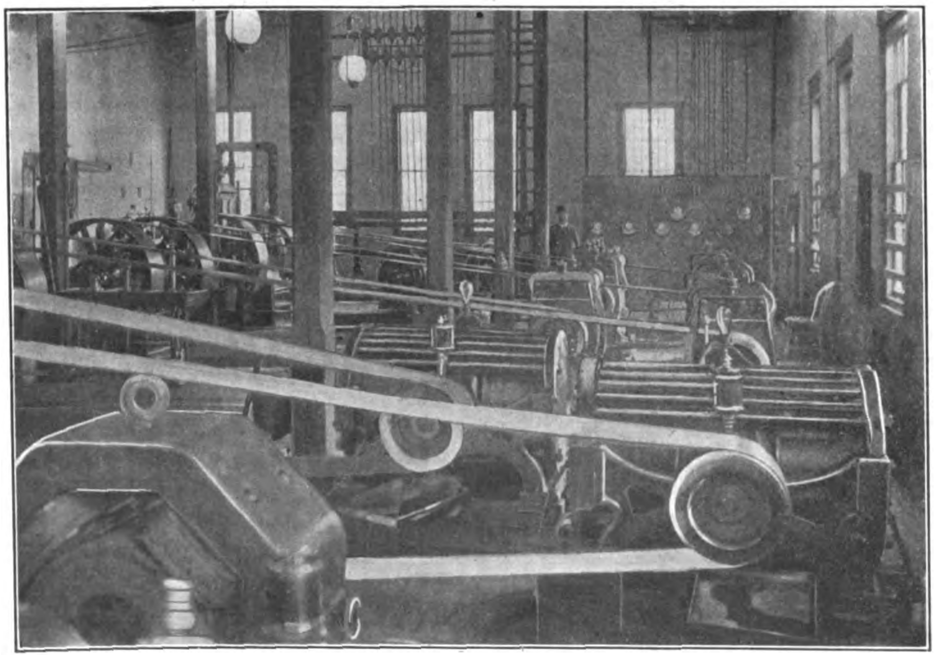


FIG. 2.—GENERATING EQUIPMENT PRIOR TO RECONSTRUCTION.

The old boilers having made a good showing under test, their immediate replacement was not considered advisable. After an official inspection, the authorities permitted the steam pressure to be increased from 80 to 125 pounds, thereby increasing the boiler capacity of the plant in proportion. A new boiler of the same type and size as those already in use was installed, and three built into a single battery. The brick casings formerly on the old boilers were removed and new steel casings provided. With a view to eventually raising the working pressure to 150 pounds, the steam piping was installed to carry that pressure. At present the boilers are fitted with flat grates and are hand-fired. Each has an independent steel stack, 3 feet in diameter and 31 feet high, giving a draft of ½ to ¾ inch of water. Uniform steam pressure is secured by a Spencer automatic regulator, which operates five butterfly dampers in the boiler flues in unison. Special provisions for blowing off the boilers have been made in connection with an oil separation system. Despite all precautions a small percentage of oily matter in emulsion eventually reaches the boilers. For the purpose of removing this a surface blow-off pipe is fitted to each boiler two inches below the water line. During the noon hour, when the boilers are quiet, they are blown off at the top and bottom, the former removing the oily matter and the latter precipitation.

By reason of the comparatively small size of the generating units a central condensing system was installed. The capacity of this is sufficient for the entire engine plant, including future units, and avoids any future encroachment upon engine room floor space, which might be otherwise necessary. The outfit, as shown in Fig. 5, consists of a Wheeler surface condenser with a 10 x 16 x 18 Deane steam air pump built onto the condenser shell. Circulating water is furnished by an independent pumping unit, entirely separating the water and air pump functions and providing an effective means of proportioning the speed of either pump to the requirements of existing loads. The water unit consists of a Morris centrifugal pump direct-connected to a 10-h.p. Westinghouse junior engine. The speed of this unit can be varied from 400 r.p.m. at full load to 160 r.p.m. or less at light loads. The pump suction extends into a brick intake well located outside of the power house. It discharges into the condenser upon the lower side, the hot water leaving the condenser at the top and escaping through a discharge pipe emptying into the brook which passes the building. Both the suction and discharge pipes are sealed below the surface of the water, so that the two water columns of the circulating system are approximately balanced, and the pump has only to work against a resultant hydrostatic head due to friction in pipes and discharges. Under normal conditions the main engines exhaust directly into the condenser, sufficient steam being supplied to the heaters from the auxiliaries.

The exhaust piping is of simple design and is constructed of wrought-iron pipe with screwed flange fittings. The main is hung from the floor beams by simple angle-iron hangers. The pipe is covered with magnesia throughout its length and slopes gradually toward the condenser so as to prevent the collection of water except at the end of the main, where a pocket is purposely formed and drained by a drip pipe leading to the bottom of the condenser shell. Atmospheric exhaust for all of the main engines is provided through an independent main paralleling the condenser main. An automatic relief valve allows steam to escape to the atmospheric main running beneath the cast-iron floor plates and up to the roof.

A feature of the plant is the system in use for separating the oil from condensed steam in order that the water may be again used in the boilers. The system embodies three main functions: mechanical oil separators in each engine exhaust, a vacuum trap, and filtration through oil-absorbent substances. Each engine exhaust pipe extends through the floor and connects with the exhaust main through the 7-in. offset in which is located a De Rycke oil separator. These separators operate on the centrifugal principle, the current of steam during its discharge being thrown into rapid whirling motion by a set of spiral vanes. The entrained moisture and oil are thrown against the interior of the separator and gravitate to a pocket beneath, which is provided with a gauge glass for observing the depth of the liquid. The oil pockets are piped through valves to an oil main which discharges into a receiving tank. The tank is air-tight with a dished head and a large gauge glass. A discharge pipe leads from near the bottom of the tank to the brook.

The system is not automatic. The receiver tank has a capacity of 250 gallons and the present accumulation amounts to about 220 gallons of fluid per day. This consists of small quantities of heavy black oil together with an emulsion having an approximate proportion of 1 to 50. A rectangular steel tank serves the double purpose of filter tank and hot well. It is approximately 3 feet x 10 feet x 5 feet, and is built of sheet steel properly re-enforced with angle iron. The filter compartment consists of a series of vertical baffles, each sliding in ways for convenience of cleaning. Between the baffles sponges are packed and held down by wire gauze. The steam from the condenser is discharged into the first partition, pursuing a zigzag course around the baffles to the hot well at the other end of the tank. Whatever oil escapes the separators is usually removed by the sponge filters and the water is then pumped directly from the hot well into the boilers. At intervals of about a week the sponges are taken out and boiled to remove the collection of oil.

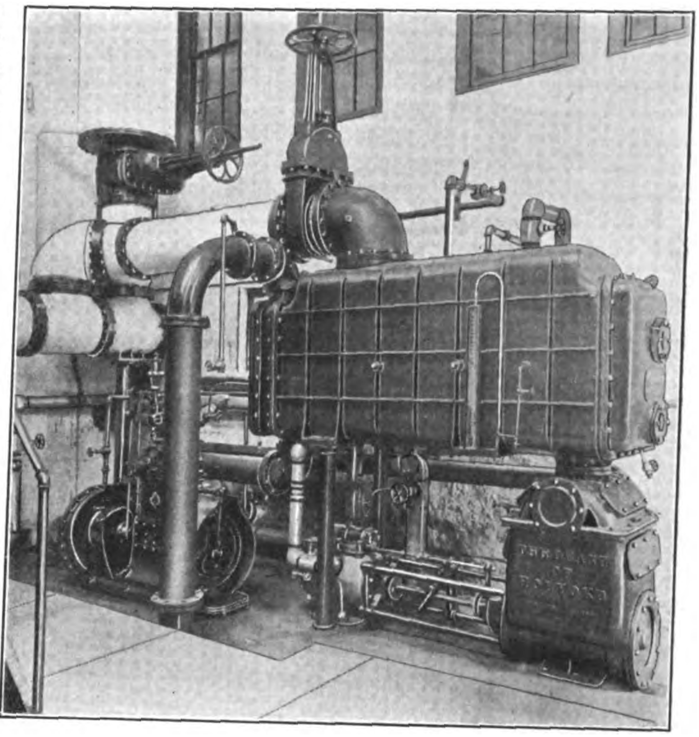


FIG. 5.—CONDENSING EQUIPMENT.

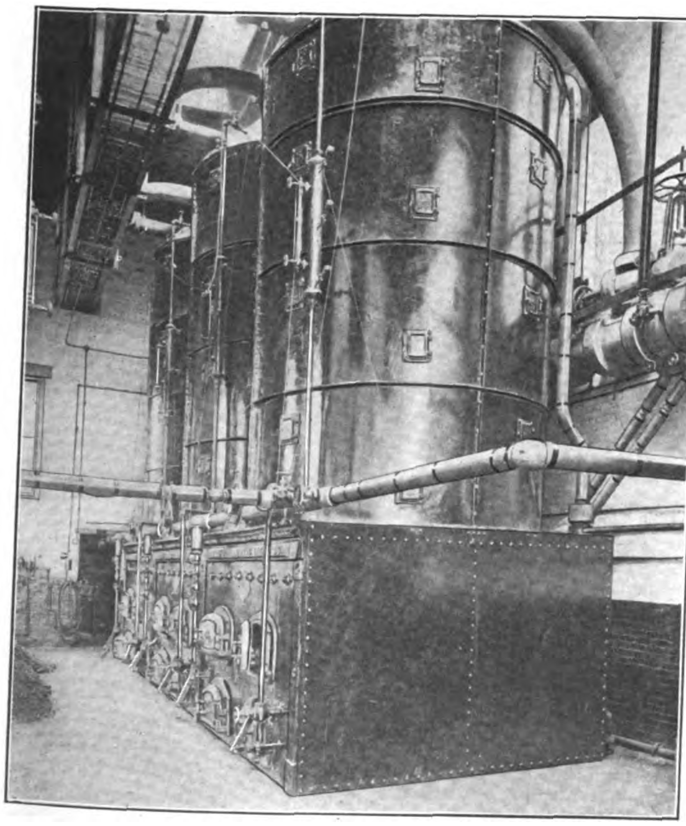
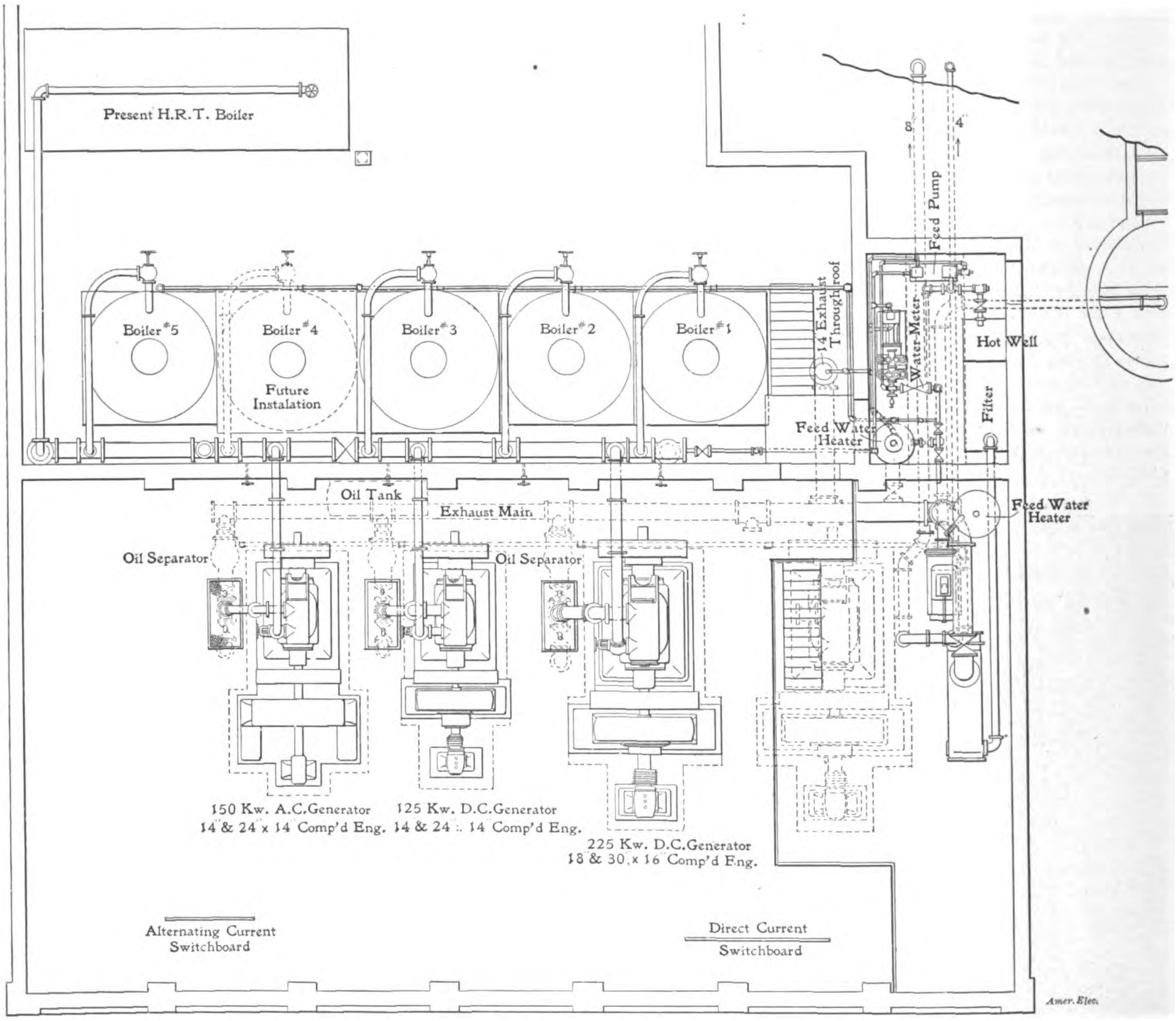


FIG. 4.—CORNER OF BOILER ROOM.

A primary heater is employed for engine exhaust and a secondary heater for the auxiliaries. The primary is a single unit and replaces the individual heaters usually employed; both are of the Whitlock induction type and have but one pipe connection to the exhaust. The primary heater, as shown in Fig. 5, is mounted vertically at the extreme end of the exhaust pipe, the influx of steam being controlled by a gate valve. Immediately in front of this connection is the exhaust line of the condenser, rising through a loop and likewise controlled by a gate valve. This latter valve performs two functions; it provides a means of isolating the heater for repairs, and insures the subdivision of the exhaust steam between the heater and condenser. In case the secondary heater is shut down for repairs, and it is desirable to supply more heat to the feed water, the condenser valve is throttled sufficiently to force the requisite amount of steam into the primary heater.

In order to prevent the heater becoming air-bound by quantities of air originally in solution in the feed water, but released in the boiler and carried over in the steam, a 2-in. pipe line connects the upper heater head with the condenser shell. As the vacuum in the condenser is slightly higher than that in the heater a positive suction head is always available. The condensation in the bottom of the primary heater is returned to the lower part of the condenser and recovered by the air pump. The secondary heater is installed in the pump room. It operates at nearly atmospheric pressure, a free exhaust pipe extending from the upper head to the roof serving as a vent. This heater has a 12-in. connection to the exhaust main from the main engines. Should the condenser system be shut down, sufficient heat may be drawn from the exhaust to heat the feed to the required temperature. Both feed pumps and the condenser pump exhaust into the secondary heater, the condensation being discharged into the sewer through a water seal constructed in the discharge line.

Feed water is drawn from the hot well by two duplex steam pumps arranged for relay service. The temperature of suction varies according to conditions and it is necessary to add a certain amount of water from the city mains to supply auxiliary and leakage losses. This supply is metered and introduced directly into the hot well, the level being automatically controlled by a float and valve. The feed water then passes successively through the hot water meter, primary heater and secondary heater, finally discharging into a feed main extending along the front of the boilers.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Hot Well
Filter
Feed Water Heater
Feed Water Heater
Oil Tank
Exhaust Main
Oil Separator
Oil Separator
150 Kw. A.C.Generator
14 & 24 x 14 Comp'd Eng.
125 Kw. D.C.Generator
14 & 24 x 14 Comp'd Eng.
225 Kw. D.C.Generator
18 & 30 x 16 Comp'd Eng.
Alternating Current Switchboard
Direct Current Switchboard
Amer. Elec.

FIG. 6.—PLAN VIEW OF POWER HOUSE.

A refinement somewhat unusual in plants of this size has been introduced with success. A recording thermometer in the feed water line provides the engineer with an accurate detailed record of the temperature of feed water entering the boilers and also serves as a silent monitor, insuring much better service from the fireman than would otherwise be possible without constant observation by the engineer in charge. The instrument is a Peabody 24-hour recording gauge, reading from zero to 240°.

Although largely an adaptation to existing conditions, the steam piping presents interesting features. A single 12-in. main parallels the dividing wall in the rear of the boilers. It is sectioned by a by-pass valve and receives its supply through long radius bends, each fitted with a gate valve at the junction with the main and an angle valve at the connection with the boiler drums. The latter are operated from a substantial iron platform suspended from the roof and the former by means of a bevel gear and hand wheel from the engine room. These are shown in Figs. 1 and 13. Engine risers are correspondingly provided with valves at the mains and at the throttle. This somewhat novel arrangement provides for the control of each boiler from the engine room and each engine from the boiler room. The mains are constructed of extra heavy wrought-iron pipe and fittings, the latter being flanged fittings screwed and pened. The main is suspended from the roof trusses and anchored at its middle point, the anchor straddling a pilaster in the engine room wall. An iron grating platform provides convenient access to all valves. At the opposite ends of the main are 24-in. sections of 12-in. pipe, which serve as vertical pockets for collecting condensation. These pockets, as well as all valve pockets in the main branch and auxiliary piping, are drained by a steam loop and Holly gravity return system located in the engine room basement. All high-pressure pipe, both steam and feed, including valves, bodies and fittings, are covered with magnesia retained by sewed canvas jackets. The exhaust main and heaters are also covered, so that the heat losses of the plant are reduced to a minimum.

All of the main engines are of the Westinghouse automatic compound type with extended shafts and outboard bearing for the reception of engine type generators. The common practice in vertical engine work, of mounting engine and generator upon a single bedplate, has been departed from and an important economy effected in the weight and cost of each unit. In determining the engine sizes, the capacity required for the alternating-current unit proved to be somewhat greater than that for the direct-current unit. It was, however, considered of greater importance to minimize the number of duplicate parts to be kept in stock than to equate engine and generator capacities. One size of engine was, therefore, chosen for driving both generators and the vertical type was practically prescribed by considerations of floor space. Fig. 3 shows a sectional elevation and Fig. 6 a plan view of the station, from which the convenience of the arrangement of the boilers and generating units is apparent. Five hundred kilowatts of generating machinery have already been installed in the engine room, and sufficient space exists for one 150-kw. alternating current and one 225-kw. direct-current unit. As the installation of the second direct-current unit will not take place for some time, the floor of the engine room was cut away around the condenser, so that in addition to better illumination the equipment may be constantly kept in view from the engine room floor.

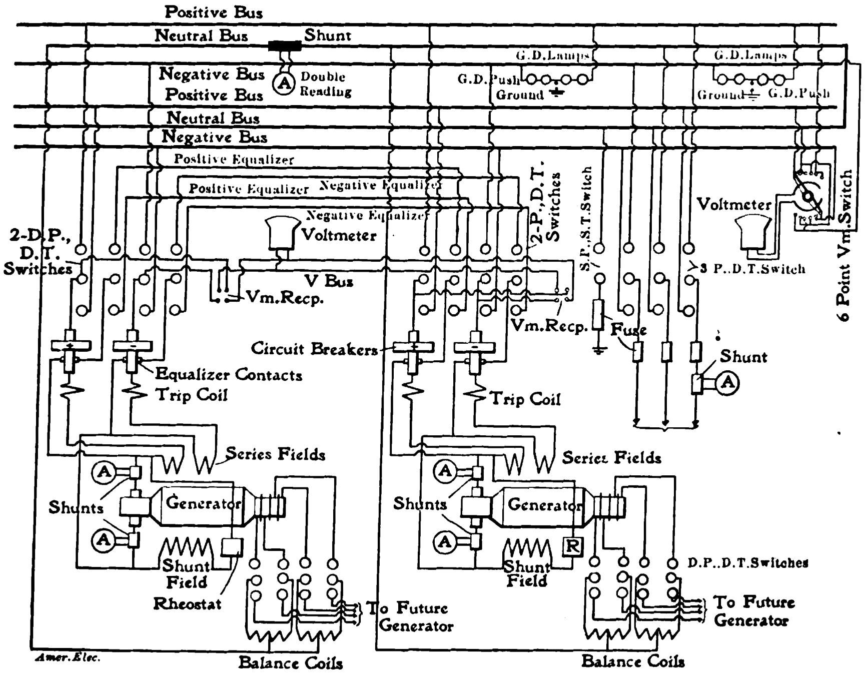
Positive Bus
Neutral Bus
Shunt
Negative Bus
Positive Bus
Double Reading
Neutral Bus
Negative Bus
Positive Equalizer
Positive Equalizer
Negative Equalizer
Negative Equalizer
Voltmeter
2-D.P., D.T. Switches
V Bus
Vm.Recp.
Circuit Breakers
Equalizer Contacts
Trip Coil
Series Fields
Shunts
Generator
Shunt Field Rheostat
To Future Generator
Balance Coils
Amer. Elec.
G.D.Lamps
G.D.Push
Ground
2-P.,D.T. Switches
S.P.S.T.Switch
Voltmeter
6 Point Vm.Switch
3 P..D.T.Switch
Vm.Recp.
Fuse
Shunt
Trip Coil
Series Fields
Shunts
Generator
Shunt Field
R
D.P..D.T.Switches
To Future Generator
Balance Coils

FIG. 7.—DIAGRAM OF SWITCHBOARD CONNECTIONS.

Views of the engine room taken from opposite ends are given in Fig. 1. The engine throttles are accessible from an iron gallery connecting the three units, and from this gallery may also be operated the exhaust and atmospheric relief valves, so that each engine is completely under control from one point. The pedestals forming the spindle guides rest upon cast-iron floor plates which may be removed if necessary so as to give access to the valves and piping without breaking the concrete floor. Each engine is supplied with cylinder oil by a gravity system actuated by positive steam pressure from the boilers. A 12-gal. oil tank is installed in the engine room basement and from its upper head a small pipe passes through the floor and follows the contour of the engine casing to a sight-feed lubricator at the throttle. From the bottom head of the tank a similar pipe follows the wall to the roof and loops back to a small auxiliary steam main connected to each boiler behind the safety valve. Steam condensing in the piping and loops provides a water column of sufficient height to overbalance the oil column and create a positive pressure at the lubricator. Crank case oil is supplied to the engines by brass hand pumps mounted on the case; these draw their supply from a tank located in the basement. The characteristics of the engines appear in the accompanying curves, which show the results of shop tests of one of the smaller engines. With unjacketed cylinders and moist steam, the economy at full load reached 22.1 pounds per brake horse-power-hour and 19.1 pounds per indicated horse-power, giving a mechanical efficiency of 87.2 per cent.

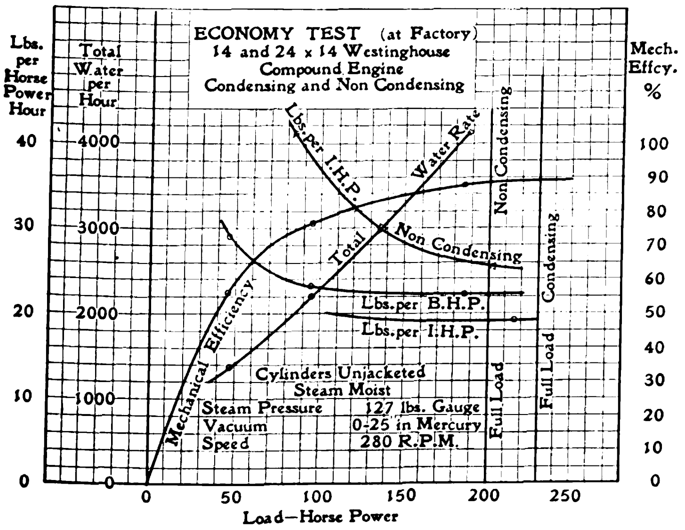

FIG. 8.—CURVES SHOWING ENGINE PERFORMANCE.

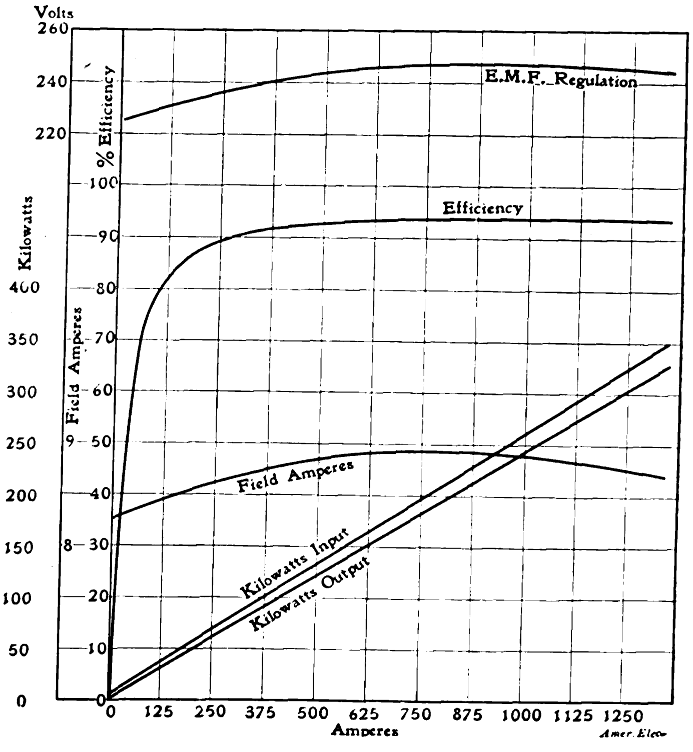

FIG. 9.—GENERATOR CHARACTERISTIC CURVES.

The general construction of the three-wire generators is almost identical with that of the standard Westinghouse 220-volt, direct-current, two-wire generators. An essential difference, however, lies in the provision of collector rings at the commutator end, which are connected to four equidistant points of the armature winding and deliver two-phase current. They thus become double-current generators, but of very low frequency. The 225-kw. machine is clearly shown in Fig. 1. It has eight poles and operates at a speed of 250 r.p.m., giving a frequency of 2000 alternations per minute. The three-wire machines operate in connection with balancing coils, through which agency the unbalanced current upon the neutral is returned to the armature winding. Fig. 7 shows a diagram of connections. The balancing coils are single-coil transformers with standard cases and laminated cores. They enable the excess currents on one branch of the circuit to return by the neutral wire and the coils to the generator armature by means of the collector rings. The electrical characteristics of the three-wire machines are shown in Fig. 9. This represents the results of shop tests under different conditions and is a regulation test with both sides of the system symmetrically loaded. The field rheostat was adjusted for a no-load voltage of 225 volts and left unchanged. The cumulative effect of the compounding is shown in the curve of field current. At full load an efficiency of 93.75 per cent. was realized, and at half load an efficiency of 92 per cent. In a test showing the balance coil characteristics, the entire load was carried upon one side of the three-wire system, the other side being left open. With constant field current and full load upon one side, the voltage of the open side rose from 112 to 118.6 volts, and that of the loaded side fell to 110.2—an unbalancing of 88.4 volts, or approximately 7½ per cent. A feature of the generator is the parting of the frame along a vertical plane, giving ready access to the armature and field windings without lifting any heavy parts. Each pole piece has three windings—a shunt coil and two series coils. One of the latter has 1½ turns and the other 2½ turns. This sequence was adopted in order to maintain an equal magnetic flux through each pole, as the compounding required less than four complete series turns. The adjustment is finally made by a German silver shunt across the terminals of the larger coil. The alternating-current generator is a two-phase Stanley machine of the rotating field type. It is fitted with iron collector rings with carbon brushes and has independent voltage control of each phase.

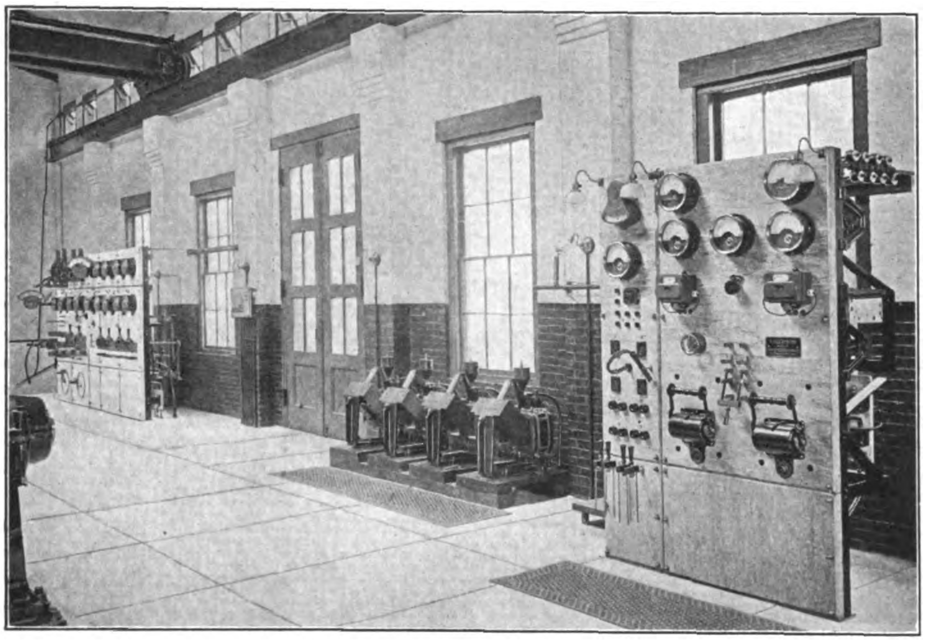

FIG. 10.—SIDE OF GENERATOR ROOM SHOWING SWITCHBOARDS AND REGULATORS.

The direct-current switchboard is constructed of half and quarter panels of blue marble. A diagram of its connections is given in Fig. 7. Main and auxiliary busses are provided with double-throw, quick-break switches for generators and feeders. Both positive and negative generator leads have separate switches, which also control a separate equalizer connection to the generator inside the series coil. This facilitates paralleling with machines running on an unbalanced load. Special circuit-breakers are employed, making four contacts—two for the main circuit and two for the equalizer circuit. Upon the center panel is a reverse reading ammeter. This is connected to a shunt in the main neutral busbar and indicates the extent and direction of the unbalanced load. The generator ammeters are connected to shunts mounted upon the terminal boards of the generators, as shown in Fig. 1, instead of upon the switchboard. All of the direct current is measured by wattmeters inserted in the various distributing feeders, a voltmeter and multiple-point switch likewise indicating the voltage at each center of distribution.

The alternating-current switchboard conforms in general construction to the direct-current board. One large panel controls the generating apparatus, which is symmetrically laid out for the two phases. Each phase is controlled by a Stanley combined switch and circuit-breaker and is supplied with a recording wattmeter, indicating wattmeter and ammeter. After leaving the board the current is stepped up to 5000 volts by transformers in the basement. It then passes through Helios-Upton constant-current regulators to the distributing panel.

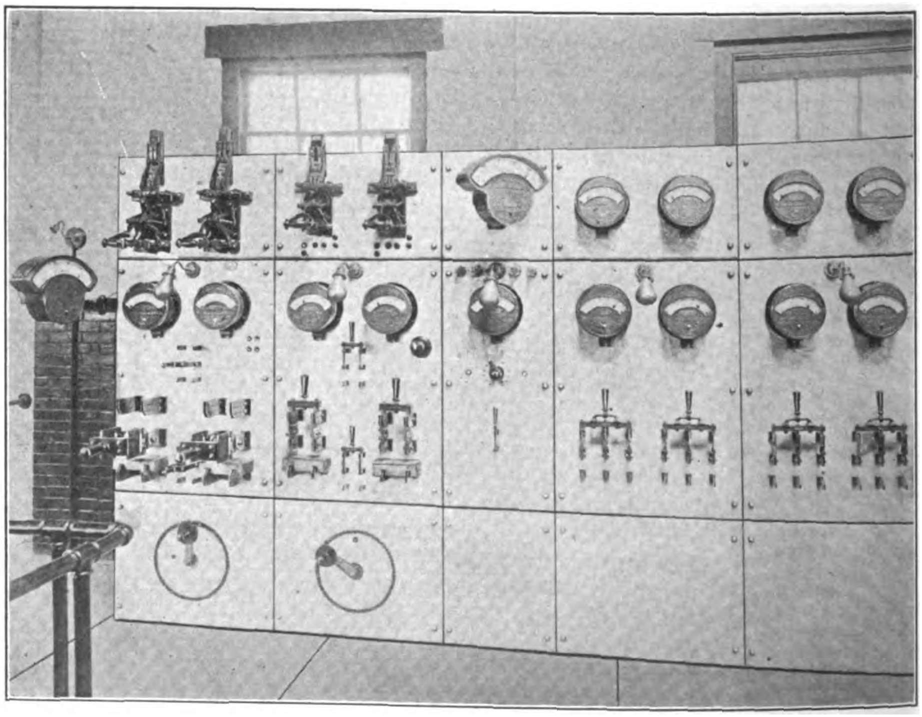

FIG. 11.—DIRECT-CURRENT SWITCHBOARD.

Each arc circuit is controlled by plug switches, and its voltage may be measured by a voltmeter fitted with plug connection to each circuit. An ammeter may be cut in series with the lamps without breaking the circuit, and an electrostatic ground detector may also be plugged in.

An effective means of breaking the field circuit is shown diagrammatically by Fig. 12. When the switch is in the upper position current passes from the main station bus-bar, and when in its lower position current passes from the auxiliary bus-bar or exciter. When the switch is thrown completely in, terminals *A* complete the circuit from the bus, but terminals *B* do not touch until the switch has just left points *A A*. The field current then discharges through the resistance, *R*, when the switch may be opened. All of the instruments are provided with transformers, so as to avoid the introduction of high voltages in the meters, with its consequent dangers.

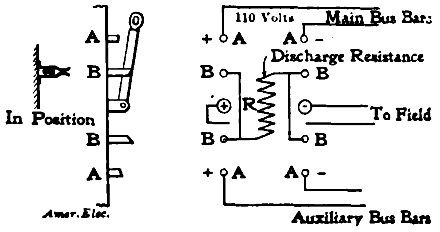

FIG. 12.—DIAGRAM OF FIELD SWITCH CONNECTIONS.

Prior to the reconstruction of the plant, 9.6 and 6.8-ampere open-arc lamps were used, the territory covered from a single station being within a one-mile circle. The line losses averaged about 20 per cent and the losses from the engine cylinder to the switchboard 30 per cent. By replacing the open arcs with 6.6 and 5.5-ampere enclosed arcs, the line losses were reduced one-third, and by changing from direct-current series to alternating-current series the total efficiency was raised to over 75 per cent. This system was installed for street arcs and the commercial arcs were transferred as fast as possible to the three-wire, direct-current system, so as to be more under the control of the customer and upon a meter rather than a contract basis. The use of an alternating-current generating unit also gave a source of power for high-voltage transmission to remote districts for light and motor service. As the limits of the street lighting load were practically defined by contract with the city and immediate extensions were improbable an arc equipment was selected of such character as to give the highest economy when operating at full load.

The three-wire, 220-volt system was retained for the incandescent service, but the losses between the station and distributing centers were considerably reduced by the addition of more copper. The balancing of the load upon the two sides of the system was experimentally determined at various points, and corrected where necessary by shifting the load upon local mains. From the station to the distributing centers the neutral is of the same size as the outer wires. Pressure wires were run back to the station, so that records of local potential might be kept. The power service is almost entirely upon the 220-volt system, and where this assumes large proportions special feeders are run from the station in order to prevent fluctuations upon the lighting mains. In anticipation of increased demand upon the three-wire system, two busses were provided upon the switchboard, the "low" bus being used for feeders serving the nearby distributing centers and the "high" bus-bar for outlying centers. The two busses may, of course, be supplied from separate generators, and the voltage of outlying districts maintained at or near parity with that in the city. At present 200 Helios-Upton enclosed-arc lamps are connected to the system. These have shunt and series regulating coils and burn electro carbons with 7½-ampere line current. The lamps average 75 volts at the terminals and 69 at the arc. The power factor of the system averages from 70 to 75 per cent.

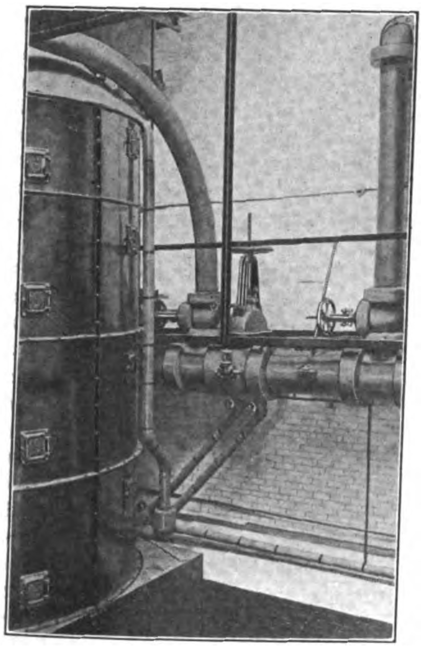

FIG. 13.—DETAIL VIEW OF STEAM PIPING.

Recent tests upon the plant and the results obtained from station records give every evidence of high gross economy in its average daily operation. The following data are taken from the station log for Saturday, April 4, 1903:

24-HOUR RUN.

Output... Arc 870 KWH. Incandescent 1397	2267
Average output	95 KW.
Load factor	19%
Coal burned	9769 lbs.
Coal per KW. hour	4.3 lbs.
Water evaporated per lb. coal	9.8 lbs.
Water per KW. hour	42.14 lbs.
Water per E.H.P. hour	31.6 lbs.

On September 3 and 4, 1903, economy tests on engine units were conducted with the following results:

TEST 1.

Duration: 3 hours—7 P.M.-10 P.M.
Apparatus: 14x24x14 compound engine.
150 KW., A.C. generator.

Load arc lamps	Constant.
KW. output average	110
% rated capacity generator	73.5
Steam pressure	125 lbs.
Vacuum	28¼"
Water per E.H.P. hour	23.52
Water per I.H.P. hour	18.81
Efficiency, combined 85.5x93.5	80% (est.)

TEST 2.

Duration: 4 hours—1 P.M.-5 P. M.
Apparatus: 14x24x14 compound engine.
125 KW. 3-wire generator.
Load: Incandescent lamps and motors.

Kilowatt output average	51.9
% capacity generator	41.5
Steam pressure	125 lbs.
Vacuum	28¼"
Water per E.H.P. hour	24.54 lbs.
Water per I.H.P. hour	18.4 lbs.
Efficiency, combined	75 (est.)

TEST 3.

Duration: 4 hours—7 P.M.-11 P.M.
Apparatus: Both units test 1 and 2.

Kilowatt output average	166.5
% capacity developed	60.5
Steam pressure	125 lbs.
Vacuum	28¼"
Water per E.H.P. hour	23.94
Water per I.H.P. hour	18.5 lbs.
Efficiency, combined	77.5 (est.)

By reason of the light duty imposed upon the condenser, a vacuum of 28¼ inches was easily maintained during the test.

On account of the excellence of these results, a confirmatory test was conducted upon the entire plant on October 3, 1903, the principal data upon which are given below. The plant was in ordinary working condition and water levels, fires, etc., were practically the same at the beginning and end of the test. The watermeter measuring feed water was checked after the test and all gauges and thermometers calibrated. Condenser leakage was also measured and found to be negligible:

ENGINE TEST—OCT. 3, 1903.

Duration: 24 hours—7 A.M.-7 A.M.
Equipment: One 18x30x16 comp. eng. and 225 KW.-D.C. generator.
One 14x24x14 comp. eng. and 125 KW.-D.C. generator.
One 14x24x14 comp. eng. and 150 KW.-A.C. generator.

Output plant	2578 KW.H.
Average electrical load	107.45 KW.
Load factor, station (electric)	21.45%
% generator rating developed	49.1%
Steam pressure	125 lbs.
Vacuum	28"
Water per hour, engines	3579 lbs.
Water per hour, auxiliaries and leakage	678 lbs.
% total station water for auxiliaries and leakage	15.9%
Gross water per E.H.P. (station)	29.55 lbs.
Net water per E.H.P. (engines)	24.84 lbs.
Net water per I.H.P. (engines)	19.9 lbs.
Gross coal per E.H.P. (station)	3.30 lbs.
Net coal per E.H.P. (engines)	2.78 lbs.
Net coal per I.H.P.	2.22 lbs.
Net dry coal per I.H.P.	2.16 lbs.
Watts per pound coal	225

BOILER TEST—OCT. 3, 1903.

Duration: 24 hours—7 A.M.-7 A. M.
Equipment: two Hazelton, vertical, water-tube boilers.

Grate surface, each	35 sq. ft.
Heating surface, each	1453 sq. ft.
% rating developed	59%
Average steam pressure	125 lbs.
Average temperature feed water	182° F.
Coal—Georges Creek Cumberland:	
Moisture	2.75%
Refuse	9.17%
Actual evaporation per pound dry coal	9.17 lbs.
Equivalent evaporation per pound dry coal	9.81 lbs.
Equivalent evaporation per pound combustible	10.9 lbs.
Equivalent evaporation per sq. ft. heating surface per hour	2.1 lbs.
Dry coal per hour per sq. ft. grate surface	8.92 lbs.

For purposes of comparison, the principal results obtained from old and new plants are tabulated herewith:

PERFORMANCE TESTS—POWER STATION.

Dates:	Dec. 23, 1901.	Oct. 4, 1903.	% saving.
Duration	21 hours	24 hours	
Load factor station	43.7	21.45	
% rating—engine	68.5		
% rating—generator		53	
Steam pressure	80	125	
Vacuum	Atmosphere	28"	
Gross water per KW.H.		39.62	
Gross water per E.H.P.	(46.0)	29.55	36
Gross water per I.H.P.	32.19	(22.5)	
Net water per E.H.P.	(44.1)	24.84	43.5
Net water per I.H.P.	30.82	(19.8)	
Gross coal per KW.H.		4.43	
Gross coal per E.H.P.	(5.02)	3.30	34
Gross coal per I.H.P.	3.51	(2.64)	
Net coal per KW.H.		3.73	
Net coal per E.H.P.	(4.79)	2.78	42
Net coal per I.H.P.	3.35	(2.22)	
Net coal per I.H.P. (dry)	3.24	(2.16)	
Equivalent evaporation per lb. dry coal	10.04	9.87	
% boiler rating	66	59	

Note: Figures in parenthesis are estimates from assumption—efficiency of old plant .70, new plant .80.

The officers of the company, through whose courtesy these data are made public are: President, Walter Hubbard; secretary and treasurer, Samuel Dodd, and manager, Charles H. Learned, under whose personal direction the tests were conducted by C. W. Brooks, chief engineer. Photographs and drawings were furnished by Westinghouse, Church, Kerr & Co., engineers in charge of reconstruction work.

THE DEVELOPMENT OF SMALL WATER-POWERS.

BY LOUIS BELL, PH. D.

From a theoretical standpoint size is inconsequential in hydraulic developments, but as a matter of practical electrical engineering small powers require very special treatment to secure good economic results. By small powers, I mean here those not exceeding, say, 500 horse-power in the water, and perhaps not over half that size.

There are hundreds of such powers scattered over the country, some on unfrequented streams, others in locations that have encouraged their utilization for driving small mills. It is altogether probable that of the total hydraulic power available for the use of mankind the major half is in these small units, which, however trivial they may seem individually, are in the aggregate of large importance.

To utilize them to advantage is by no means a simple problem. On the contrary, it requires quite as much skill and finesse as if they were fifty times as big. In the first place a small water-power requires extremely careful investigation to determine the limits of flow, for both the flood and low water conditions are far less certain in small than in large streams. In fact, the smaller the stream, the more acute is the necessity for accurate gauging and comprehensive knowledge of past conditions, and the less valuable is general reasoning based on watershed and rainfall. An immense watershed of diversified country tends to average the conditions, while separate bits of it may present great variations. For example, the Merrimac, with a watershed of somewhat over 4000 square miles, has an annual average minimum flow of just about one-half cubic foot per second per square mile of watershed, while some of its smaller confluents will fall to considerably less than half this relative flow; and not only this, but confluents within a few miles of each other and apparently draining somewhat similar districts will show enormous variations in relative maximum and minimum flow. Hence, the first thing to do in dealing with a small power is to make an exceptionally thorough study of its flow, so that one may not be fooled into putting in a plant that will be useless a good part of the summer. And besides, the smaller the absolute flow of a stream, the more likely on the whole is it to give great variations of flow, so that a small power with a relatively considerable head is particularly open to suspicion. On the other hand, the higher the head the easier it is to store power in a pond, and storage is often exceptionally easy in small streams, so that small size may have its compensations.

To bring a discussion of the matter down to concrete terms, assume a stream having a reliable flow of 100 cubic feet per second during the dry months, and a working head of 25 feet, and see what can be done with it. Its mean yearly flow may be twice this figure and its maximum flow, say, 400 cubic feet per second. This would be a relatively steady stream for its size, as water-powers go. To make the hypothesis more complete, also assume that in very dry years, like 1900, in the New England streams, the flow might drop to 75 cubic feet per second for some days at a time.

Now what can be done with a power of this kind, and how should one go about it? The first question to take up is the amount of power that can be derived from such a fall, taking into account storage. To start with, the assumed average minimum flow will yield just about 225 horse-power when utilized in a first-class turbine. The electrical product of this power, a little over 150 kilowatts, can be sold twenty-four hours per day, save for a few days at a time in very dry years. A large part of the year, say nine months, twice this output could be delivered from the natural flow of the stream. But few industries, however, require 24-hour power, and few of these could take to advantage the surplus power during the months of good flow, say, from October 1 to July 1 succeeding. An electric lighting plant, with its demand for night power only and relatively small output during the summer months, is a far better customer under the circumstances. The first inquiry to be made is how far storage can be brought into play to build up an output big enough to be of some use.

With a normal minimum flow of 6000 cubic feet per minute, the working power for a 12-hour run can be doubled by storing a little over 4,000,000 cubic feet of water. This would mean drawing down a 100-acre pond one foot at night and letting it fill up when the load is substantially off during the day. In a very dry year there may be a further deficit of flow amounting to a little over 2,000,000 cubic feet in each twenty-four hours. Six inches on a 100-acre pond will take care of this for a day, so that if by putting flash boards on the dam the water could be raised two or three feet in a 100-acre pond, the plant will be made practically safe for over 300 kilowatts steady output on its lighting load. Therefore, the storage pond must be planned for if feasible. The only way to do this is to survey the stream above the fall and find out the facts accurately. A good rule in all such cases is: *Do not guess—know.* Then, and not until then, is one justified in going ahead. With the pond thus available, one can run 300 kilowatts steadily through every night of the year with only the minimum flow of the stream to depend upon. This does not allow, however, for any day load. Evidently, if one should draw off the water by day at the rate of 6000 cubic feet per minute the pond would have no chance to fill up. Here comes to the rescue a well-known feature of electric light loads, the "peak" which comes late in the afternoon in winter and in the early evening all the year around. The late afternoon peak will not concern us just now for it comes on only after the season of low water is usually over, but if the summer and early autumn peak in the evening has the usual form and does not rise too high, the average late night load will be much less than 300 kilowatts, and there will be so modest a draught on the pond that a fair day load may be carried, perhaps as much as 75 or 100 kilowatts, certainly enough to do the ordinary day work of a company that does not aim at going into the motor business.

Assuming 1800 kilowatt-hours to be stored in the pond for one foot of depth, the distribution of the demand for this storage may be anything one pleases. One might even draw out 300 kilowatts for three hours and still have 900 kilowatt-hours left for the rest of the night, over and above the basic 150 kilowatts from the minimum flow. This would allow a total output of 450 kilowatts during the hours of heavy load, and would leave 2250 kilowatt-hours for the rest of the night and for the small day load. This amount is relatively much larger than experience indicates for a peak of 450 kilowatts, and as a matter of fact it would be perfectly safe to allow for a peak running up to 600 kilowatts in all, of which 450 would be from the storage. A plant with a peak capacity of 600 kilowatts is capable of doing the lighting work of an average city of 25,000 or 30,000 inhabitants, and furnishing incidental light power. If the service is by meter, as it always should be, 600 kilowatts will go a long way and earn a large return.

Up to this point merely the usual minimum flow of the stream has been assumed as the basis of computation. For nine months of the year, double this flow can be counted on, so that the storage of water in the pond is easy, and ample power is available. It would be quite possible, in fact, to raise the peak capacity to 750 kilowatts, save in the dry months, and the extra high peak in the winter months is therefore easily taken care of. If the output is based on a consideration of the maximum load required in the dry months, one is quite safe for the rest of the year. In certain parts of the country the low water season is due to freezing up of sources and falls in the winter, which fact must be taken into account when it exists.

Summing up, it is found that a minimum of 100 cubic feet per second will fully justify a 600-kw. lighting plant if proper storage can be secured. As to dealing with times of extreme minimum flow, it has already been pointed out that a little extra depth in the pond will care for this contingency. If this cannot be readily obtained, a small auxiliary steam plant will accomplish this and also serve as a safeguard in case a wheel has to be shut down for repairs. Such a plant need not deliver more than 100 kilowatts and should be planned for quick steaming and low first cost regardless of high steam economy.

It may seem that a disproportionate amount of space has been given to the preliminary steps on the hydraulic work, but in the utilization of such small powers storage is more than half the battle, and when the hydraulic proposition is well worked out the rest is easy. In this instance the 100 acres of storage approximately doubles the earning capacity of the plant.

As regards the development of the power, small streams like the one under consideration generally do not call for large expense. For the dam a well-ballasted timber crib is to be recommended, with special attention given to secure foundations and abutments. Such a dam is cheap and secure, and if well built, will last for many years. The less penstock, the better; if the water has to be conducted some little distance a deep open canal or flume should be used when practicable. Very often the power-house may be placed close to the dam, care being taken to locate it out of the way of floods, and where floating ice cannot be carried over upon it. With a good pond above the dam, the ice danger is minimized.

When the hydraulic arrangements for water supply are settled, the main question which arises is the size and number of wheel and generator units to be installed. As to the number of units, there is a simple rule which generally gives good results. Choose such a number that the temporary crippling of one will not cause serious inconvenience. As electrical generators are now generally built and rated, this rule would indicate that the total capacity should be put in, say, four 150-kw. machines. Any more than this would probably lead to increased expense, and any less might cause too severe an overload in case a hot bearing compelled shutting down one machine. Procure a set of catalogues of water wheels and electrical generators and get to work. It is here assumed that the electrical distribution is to be on the polyphase alternating system in some form, so that the generators will all be substantially alike. A brief inspection of the water wheel data shows that the required maximum power per unit, about 275 to 300 horse-power, can be obtained from a single horizontal wheel under 25 feet head at about 200 r.p.m., or from a combined pair of smaller wheels, at about 300 r.p.m. Either combination with a dynamo would do well, but the single wheel would be somewhat cheaper. Upon overhauling the dynamos, it will probably be found that a 150-kw. generator can be had for either speed, the 200-r.p.m. machine being somewhat the more costly of the two. It very often happens that this difference in cost will nearly or quite offset the increased cost of the double wheel, and as there is little choice in other respects in this case, cost usually determines whether the lower or higher speed is chosen. Sometimes the relative dimensions or weights of the wheels and generators may be factors in the choice; the writer's preference would be for the pair of wheels at the higher speed, as giving little thrust on the wheel shaft and giving also a somewhat more compact set. However, in the present case there is little choice, and once the units are selected the next step is to lay out the general arrangement of the power-house. There is a strong tendency, especially among the inexperienced, to put up a rather elaborate building at great expense, with a lordly view to future extensions. In the case in hand, the cost of plant should be kept rigidly down to hard pan, and the building should be merely a strong and tight cover for the apparatus with comfortable room for the contents and no more. One may build with a view to making small additions, but all space over and above that required for the easy operation of the apparatus is waste space, and must be paid for. Ample and well-lighted floor space must, however, be provided for the switchboard. Floor space in this connection is used advisedly, since there is no sillier fad than the erection of a switchboard gallery in a small plant. Even in large plants it is of dubious value unless the whole board is relayed so that the operator can sit with it under his fingers.

The switchboard should be placed where it commands a good view of the whole plant, and where it can be reached in about three jumps if anything goes wrong. Besides this, it should be so arranged that every inch of high-voltage wiring can be seen at a glance. If the plant is merely of the usual 2300-volt description the wiring can be made safe, and extreme care in locating it is not necessary, but if there is a transmission of even a few miles, the line voltage will probably be 10,000, or thereabouts, and the wires should then be so placed that they can be quickly traced and inspected up to the point where they leave the building.

In the matter of station construction, a simple brick building is preferable, with an iron roof or else a wooden roof tinned instead of shingled. In a cold climate the latter is more desirable, and on the whole it is preferable to iron in stations of moderate size. Of course, wiring must be kept away from wooden roofs any way, but that is an easy matter. The foundations for wheels and dynamos require the greatest attention in building a station. Their character depends on the arrangement of the units, but if you err, err on the side of extreme solidity. A somewhat flexible coupling is generally used between wheels and generators, but one should build the foundations and line up the machines as if a flexible coupling had never been heard of.

The station floor is often to be seriously considered. It is very hard to get a fireproof floor that is desirable in other respects. Brick and cement soak oil until they are inflammable, and so does wood, of course, even when fire-proofed. On the whole, a wooden floor answers as well as anything for a small plant. It is a simple matter, since the dynamo foundations rise a little above the floor, to provide means for rapidly flooding the latter to the depth of an inch or so, which ought to obviate all serious danger of fire.

Thus far, nothing has been said about the electrical "system" to be employed. On the hypothesis with which the preliminary discussion was ended that the power was to be developed almost entirely for lighting, the system cuts comparatively little figure. If the water power were right at the market, even direct current might answer the purpose.. Generally, utilizing a water power in these days means a transmission of at least a few miles, and this implies alternating current. If the distance is moderate and the management has strength of mind enough to enforce the use of loose pulleys on all but the smallest motors, a straight single-phase system answers perfectly well; but usually even when a plant starts with the intention of going light on motor work it is cajoled into doing more of it than can conveniently be done with single-phase motors, and in at least nine cases out of ten it is advisable to use a polyphase system. The voltage of the primary lines may be, of course, almost anything. If the transmission is but two or three miles it is generally best to avoid a voltage higher than can be used for the general distribution around the town. Generators for direct distribution are commonly wound for about 2300 volts, although 3300 is sometimes used where the load is in large units, so that the extra cost of 3000-volt transformers is small.

In the majority of developments from small water powers, the distance of transmission is too great for direct supply, and the actual distribution is carried on from a sub-station. At the present time there is little reason to use less than 10,000 volts for a transmission line, unless one goes underground; in fact, 10,000 volts is the common standard for transmissions of moderate length. It can be successfully worked in any climate, and as a matter of experience, 10,000-volt lines properly constructed give no more trouble than those at considerably lower voltage. In a practical lighting plant line troubles occur far more often on the distributing system than on the transmission line itself, since the former must be carried under all sorts of troublesome conditions, while the latter is generally a simple straight-away piece of construction in fairly clear country.

The transmission line, however, deserves a great deal of care, as upon it depends the continuity of the supply. As a rule, it is desirable to carry the line along a public road to insure proper accessibility, with perhaps some cut-offs to shorten the line. A small plant requires just as much land for its right of way as a large one, and the cost of acquiring this is often unreasonably high. Whatever the location of the line, it must be kept clear of interference. Trees constitute the main difficulty, as by far the largest number of interruptions come from this cause. Liberal use of the axe will obviate many a break-down, and extra high poles often do good service. It is not enough that the line should be far enough from branches to avoid contact in high wind; it should be clear enough to make it improbable that a broken branch could blow across the wires. Even a branch as big as a lead pencil lodging on a 10,000-volt line will frequently bring down a wire before it gets through.

The transmission line should be brought as near to the center of load as is possible without going underground. There is a deal of absurd prejudice against letting a high-voltage line run down to its sub-station in a city or large town, and telephone men and fire underwriters of the stupid hide-bound sort are eternally working by fair means and (sometimes) foul to block high-voltage work of every sort. In point of fact, the fall of a wire from the main transmission line upon other wires, or upon anything directly causing a fire risk, is an accident almost unknown. Other wires may cross a transmission line and cause trouble, but practically they will cause no more trouble at 10,000 volts than at 2000, either being sufficient for a serious cross. The primary distribution lines are the seat of whatever trouble the plant may have, except in very rare instances.

After reaching the sub-station and passing the step-down transformers, the energy is treated just as if it were generated at the sub-station. We need not here enter upon the general topic of central station working, but need consider it only in so far as it is influenced by dependence on a limited water power. If in the case in hand the market is such that the demand is likely to soon exceed the capacity of the hydraulic development, the matter of supplementary steam power must be considered. Water power plants have the property of showing nearly constant gross charges, irrespective of the output, and hence every effort should be bent towards utilizing the hydraulic plant to its fullest capacity. Trouble generally comes through the peak of the load rising beyond the capacity of the plant while the general output is still moderate. Therefore, in working up a small water power, it pays to use all manner of finesse to keep down the peak. This was the reason for the warning already given against going in much for motor service. The motor load laps over upon the lighting load and limits the output without adequate return. Sometimes special contracts can be made for motor service cut off at dusk, and for the sale of surplus power during perhaps ten months in the year. All possibilities of this sort should be patiently exhausted before embarking upon the supplementary steam plant proposition. Sometimes the supply can be eked out to advantage by a rotary converter and a storage battery, but the nature of the help required depends on local conditions that do not lend themselves to general discussion.

If a supplementary steam plant is down in the cards, the sub-station ought to be located with this in view, for a steam plant thus used needs to be capable of economical running, while a mere auxiliary for occasional use, as already noted, demands far less in precautions for economy. Do not confuse the requirements of the two cases; a plant which meets the one will not necessarily meet the other. If the steam plant is to assume part of the daily load for several months, at least, per year it must be a pretty good plant, while almost any sort of equipment will tide over a few days of exceptionally low water, or let one shut down over Sunday to put in work on the hydraulic plant or the transmission line. The question of a complete steam reserve sometimes comes up, but in small plants it rarely deserves consideration. One cannot fairly ask of a hydraulic plant any more elaborate precautions than should be demanded of a steam plant, and there are very few of the latter that could not be temporarily shut down by accidents no more unlikely than interruptions of service on a hydraulic plant. The whole question of supplementary or auxiliary steam plant is one that requires much skill on the part of the engineer and cannot be subjected to any simple rules.

Small hydraulic plants, as a whole, require fully as careful engineering as big ones. Success very often depends on the feasible storage, as the data here discussed plainly show. Twenty-four-hour power, therefore, is not a desirable field for small plants. Sometimes it pays to develop them mainly for motor work, but in such cases they cannot take on lighting freely on account of the "lap load," and lighting is the more profitable field. The extent to which extra capacity can be put in to care for lap load depends entirely on the local conditions. One should particularly shun the common error of taking on large blocks of motor work at low figures to insure an immediate addition to the income. Small customers pay better and give a more uniform load.

In most instances powers as small as that here considered cannot be "promoted" or "financed." They are proper and often profitable fields for private investment, or for small syndicates forming close corporations. It sometimes pays to develop them purely for private use in manufacturing, under conditions giving a nearly steady load. In this case the matter of storage must be treated as already explained, and there is the additional chance of using the surplus power to good advantage. A further possibility is the utilization of two or more small powers on the same stream. When this is done the electric plants can readily be worked in parallel, and the chance for additional storage utilized. A volume could be readily written on the questions met in these small plants, but enough has been said in this paper to emphasize the importance of looking into all the available small powers. The higher the head, the greater the chance for storage, and as a rule the cheaper is the utilization. Each year makes water powers more valuable, and big or little, they should be scrutinized and their possible development considered.

ELECTRIC TRACTION ON CANALS.

The field which electric traction on canals opens to a well-managed company is well illustrated by the brief experience of the only commercially operated system of mechanical traction on canals in this country, that of the Miami & Erie Canal Transportation Company. The company carries on business under a thirty-year franchise which requires the system of electric towing to be in operation between Cincinnati and Toledo on the Ohio State canal within six and one-half years of the date of the grant. The speed is restricted to 4 miles an hour, and the company is required to tow boats for other owners at a reasonable charge. The distance from Cincinnati to Toledo is about 244 miles, and of this route the portion between Cincinnati, Hamilton and Middletown, about 42 miles is now in operation. The company owns seven Westinghouse-Baldwin locomotives and a fleet of twenty boats, which it is increasing as fast as possible, for its facilities are altogether too small for the business offered. One reason for this is doubtless to be found in the organization of a complete freight handling service with freight houses and other conveniences for shippers.

This traction system is particularly interesting because it is carried on along a canal which was generally believed to have outgrown its usefulness. It was built in

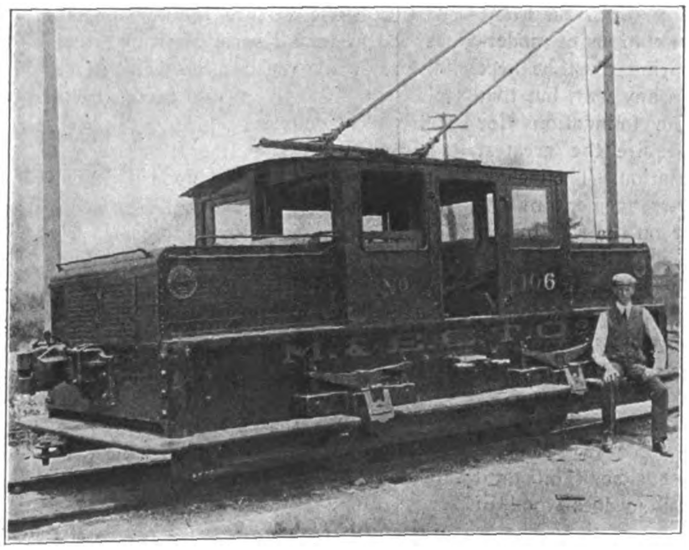
FIG. 1.—STANDARD CANAL LOCOMOTIVE.

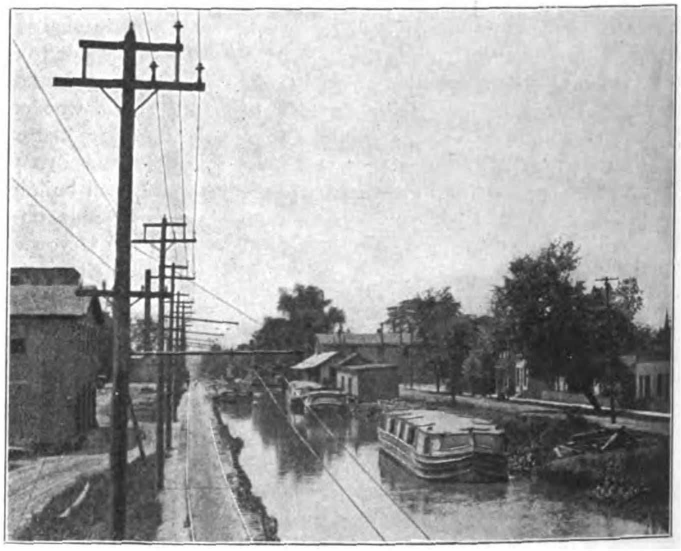
FIG. 2.—VIEW ALONG CANAL, SHOWING LINE AND TRACK

1828-44 and was leased in 1861 to a private corporation. The lease was abandoned in 1877, and by that time the waterway had suffered injuries which are not yet wholly repaired. Some time ago Thomas N. Foredyce concluded that the many manufacturing corporations along the route of the canal would furnish sufficient freight for a good transportation business provided modern facilities for handling it were afforded. He accordingly conducted experiments in 1900 which showed that electric traction was entirely practicable and the company is the outgrowth of these experiments. The company is assisting the State to clean out the canal and repair the locks and bridges, and there seems to be a good prospect that these old waterways will soon be the scene of a busy traffic.

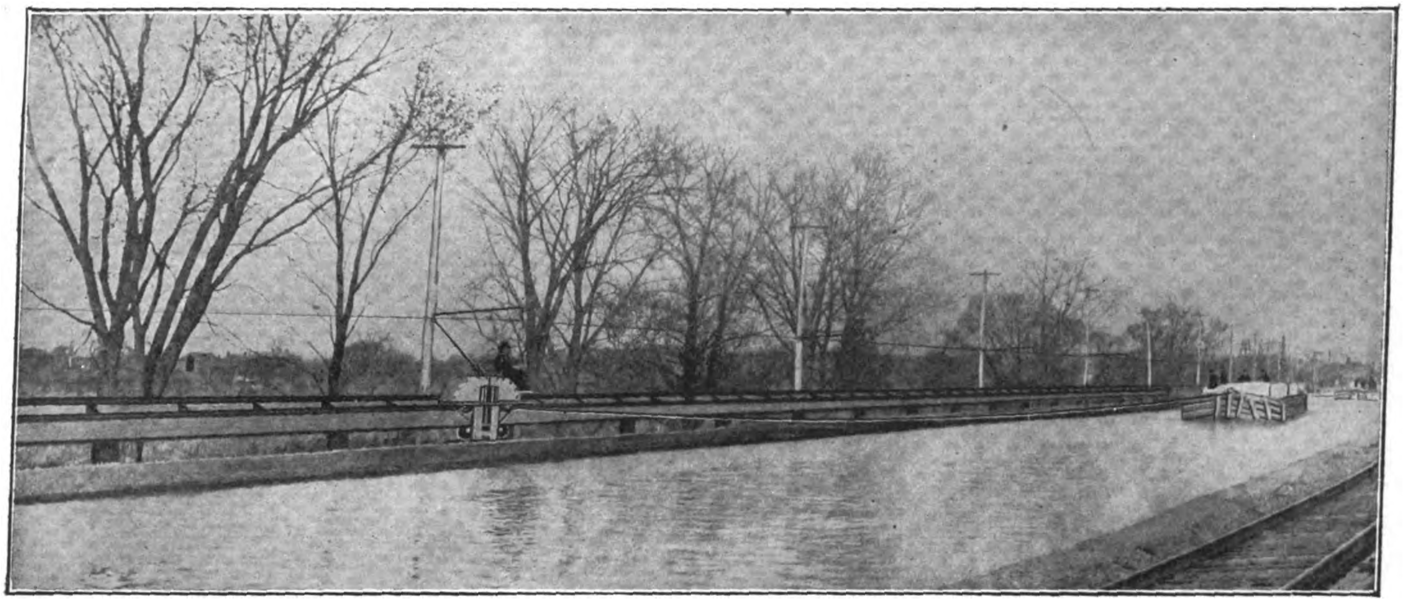

FIG. 3.—MONORAIL ELECTRIC MOTOR TOWING FOUR LOADED CANAL BOATS ON THE ERIE CANAL.

A standard-gauge track with 70-pound rails has been laid along the towpath for the locomotives. There are 134 bridges over the canal and track on the Cincinnati-Dayton division, many of which could not be raised. At such places a concrete wall was built between the canal and the track, and the latter depressed to allow the locomotive to pass below the structure. A special switching locomotive has been built for use in Cincinnati where the headroom is so small that the standard locomotives used on the canal cannot be employed satisfactorily, even with depressed tracks. The center line of the track averages about 6 feet from the water's edge and is about 2 feet above the water level, this elevation being necessary because a tow of boats making from 3 to 4 miles an hour will raise the water more than 12 inches for several hundred feet ahead. This happens in a channel nominally 4 feet deep, 26 feet wide at the bottom and 40 feet wide at the water surface. The maximum curvature of the track outside of the cities is 25 degrees and the maximum grade is 2 per cent. Ten boats is the largest number that can be handled, owing to the curves and locks, and five is about the maximum number now employed.

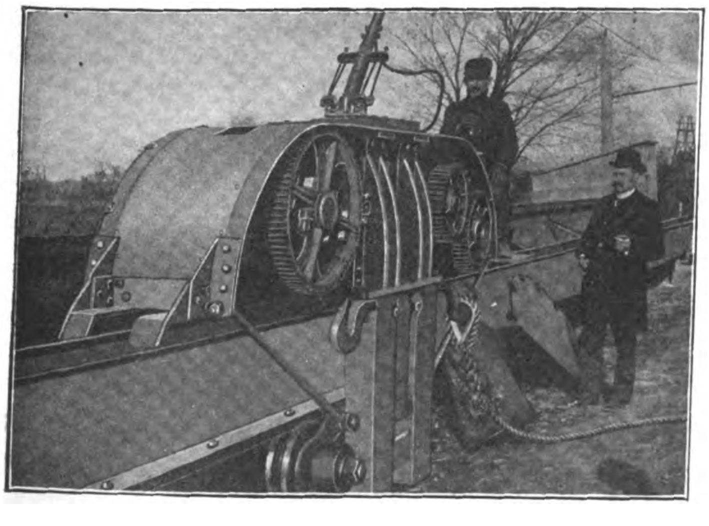

FIG. 4.—TOWING MOTOR WITH PART OF CASING REMOVED.

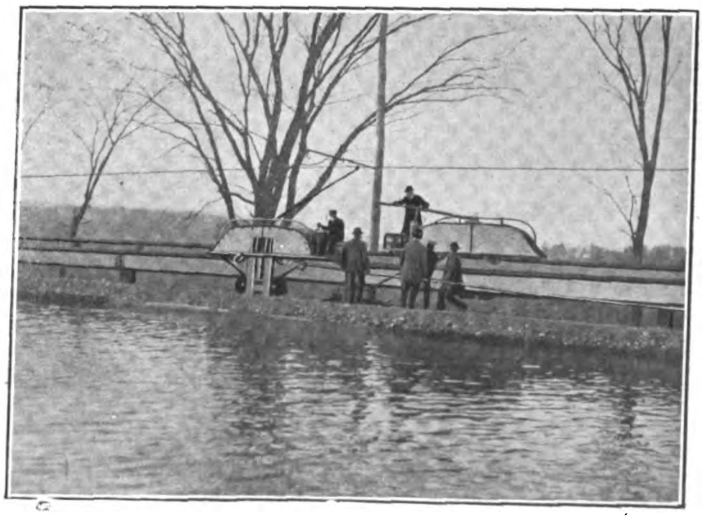

FIG. 5.—VIEW SHOWING TOWING MOTORS PASSING EACH OTHER.

The nature of the service is exceptional and enabled the engineers to adopt an unusual system of power distribution. The transmission is for long distances in a single line, and the load consists of a small number of heavy train units which may become bunched by the traffic conditions. The power demand of each unit is steady and continuous, and all conditions were favorable to the use of alternating current motors, with high trolley voltage and static transformers on the locomotives to keep the motor pressure low. Stops are infrequent and it is necessary to start a tow of boats slowly, which makes it possible to use induction motors to advantage. The locomotives have accordingly been equipped with three-phase induction motors, supplied with current through two overhead trolley wires and the track system.

As the canal passes through eighteen cities with a total population of over 650,000 persons and a number of central stations, the Transportation Company does not need to build a power station for its own use. For the current for the first section now in operation a contract has been made with the Cincinnati Gas & Electric Company. Three-phase 60-cycle current at 4200 volts is transmitted over the Transportation Company's line to a station 5 miles distant. This has three 150-kilowatt 60-cycle oil-cooled transformers, one of which is a reserve. They furnish current to a 450-h.p. 390-volt motor which drives a 300-kilowatt 390-volt three-phase 25-cycle generator, with a belted 40-h.p. starting motor. This generator furnishes current to the Cincinnati section of the canal and also to three 250-kilowatt oil-cooled transformers which raise it to 33,000 volts for transmission to the four reducing stations about 12 miles apart needed on the Cincinnati-Dayton division. Aluminum cables are employed for this transmission. Each station contains three 150-kilowatt 25-cycle oil-cooled transformers which reduce the voltage to 1170 volts. The trolley circuit consists of two No. 0000 copper wires. No auxiliary feeders are used on the 1170-volt sections, but in the 390-volt section in Cincinnati an aluminum cable equivalent to No. 0000 copper is in multiple with each trolley wire for a distance of 6 miles.

The electric locomotives are of the four-wheel mining type and weigh about 55,000 pounds. Each has two 80-h.p. induction motors, with double reduction gears, and three self-cooling oil transformers. The locomotives are 14 feet long, 8 feet 4 inches wide and have a wheel-base of 7 feet. They have a M. C. B. coupler at each end for switching freight cars, and a heavy hook on each side for the tow ropes.

The boats are 80½ feet long, 13½ feet wide and 9 feet high, over all, and can carry about 65 tons on a 3-foot draft. In the present condition of the canal it is not considered advisable to load them to a deeper draft than 30 inches, at which they will carry about 50 tons. As the first application of alternating-current motors to traction purposes in this country, the work is of unusual interest.

From time to time various attempts have been made to apply electric traction to the Erie Canal, and notwithstanding that canals on the Continent have been thus equipped the famous waterway between Albany and Buffalo is still dependent upon mules and a few steam canal boats for its motive power. Ten years ago F. W. Hawley equipped an old steam canalboat with two Westinghouse electric motors which were used to drive the propeller. Two trolleys took current from cross-span wires on a pole line running along the canal bank near Rochester. The test, although serving the purpose of showing that electric traction was possible, had the disadvantage of causing undue suction and wash, which at any reasonable speed was detrimental to the banks of the canal. Sometime afterward Richard Lamb introduced an ingenious telpher system, which traveled on a cableway along the tow path. The system was shown in operation at Tonawanda and also on the Raritan Canal in New Jersey, but for various reasons was not further developed. The latest system to be tried on the Erie Canal was recently shown in operation opposite the works of the General Electric Company at Schenectady, by the International Towing & Power Company, of New York. The system was devised by S. W. Wood, and has an experimental track about 2700 feet long. It consists of a towing car mounted on an elevated track somewhat after the fashion of the monorail systems. Stout posts are set in concrete and spaced about 25 feet apart. These follow the contour of the canal, and carry a double line of 18-inch steel girders about 3 feet apart horizontally, one line on each side of the posts. These girders are cross-braced and the one next the canal is somewhat lower than the other. The top and bottom flanges of each girder carry 3-inch rails which together serve as the track for the towing car. A row of poles and brackets supports an overhead trolley wire from which current is taken.

The car is 10 feet long, 2 feet wide and rises about 3 feet above the rail. It runs on two 22-inch grooved wheels, each driven by a 40-h.p. street car motor through a set of double reduction gears having a ratio of 40 to 1. A heavy arm extends downward from the body of the car and carries springs that cause a pair of grooved wheels to press upward on the lower rail. The springs can be adjusted so that the grip of the car on the track will be sufficient for any reasonable traction.

The current is taken from the overhead wire by means of a trolley arm such as is used on mining locomotives, and its application is controlled by a series-parallel controller with a few steps and by a resistance box located at one end of the car. The power is furnished from the General Electric Company's plant at 475 to 500 volts, one wire serving for the cars on both tracks. The boats are hauled by tow-ropes attached to hooks on the body of the car.

Not much information concerning the amount of current required for towing has been given out yet, but the trials show that the operation of the system is entirely practicable. Two boats weighing with their loads about 600 tons were hauled without any difficulty at a speed of 4¼ miles an hour. Four loaded boats were also hauled readily at about the same speed and without creating any appreciable wash. During the tests one or two mule tows passed in the opposite direction, making barely a mile an hour. No trouble was experienced in passing, and none is expected with tows handled by cars, for the greater elevation of one of the tracks enables the tow ropes to be crossed without any trouble, while it is a simple matter to hold down the trolley arm of one of the motors long enough for the other to pass.

The New Douglas Exchange of the Chicago Telephone Company.

Recognizing the fact that the value of any telephone system to the individual subscriber increases in the same proportion as the number of people which that subscriber can reach, the Chicago Telephone Company has pursued a policy which aids such growth. To give the best service and to serve the public as fully and as broadly as possible, have been considered of paramount importance. To further encourage the use of the telephone, a wide range of rates has been adopted whereby the service is brought within the means of every one.

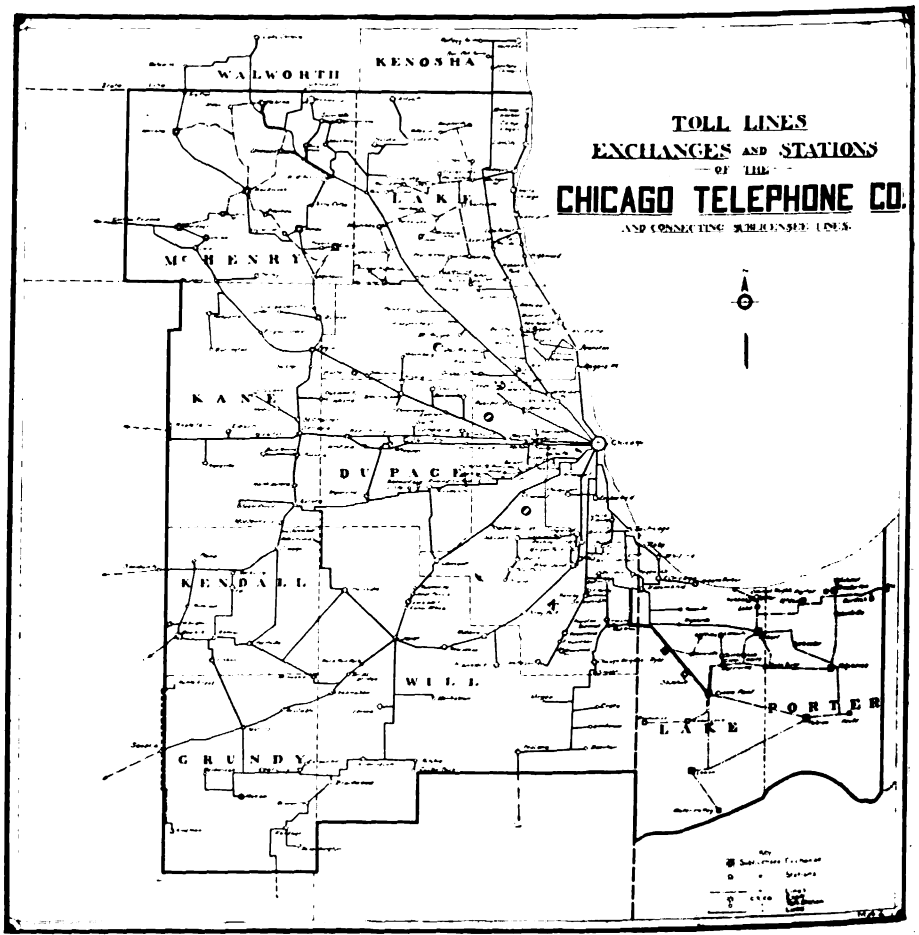

FIG. 1.—MAP OF TERRITORY COVERED BY CHICAGO TELEPHONE COMPANY.

Due to the liberal policy pursued and to the rapid growth of the city, the Chicago Telephone Company, during the last five years, has witnessed a remarkable development. Although the territory served has not been increased, the number of stations has been more than doubled and it is expected that with the present rate of growth, the number of telephones connected will reach the 100,000 mark the first of the year. Of these, 75,000 will be connected with the exchanges in the city, whereas the balance will be installed in suburban towns and villages near Chicago.

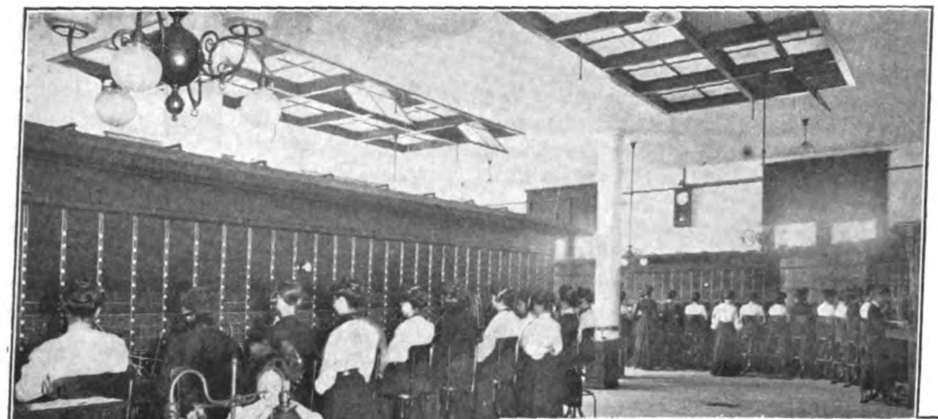

FIG. 2.—ONE SIDE OF SWITCHBOARD ROOM.

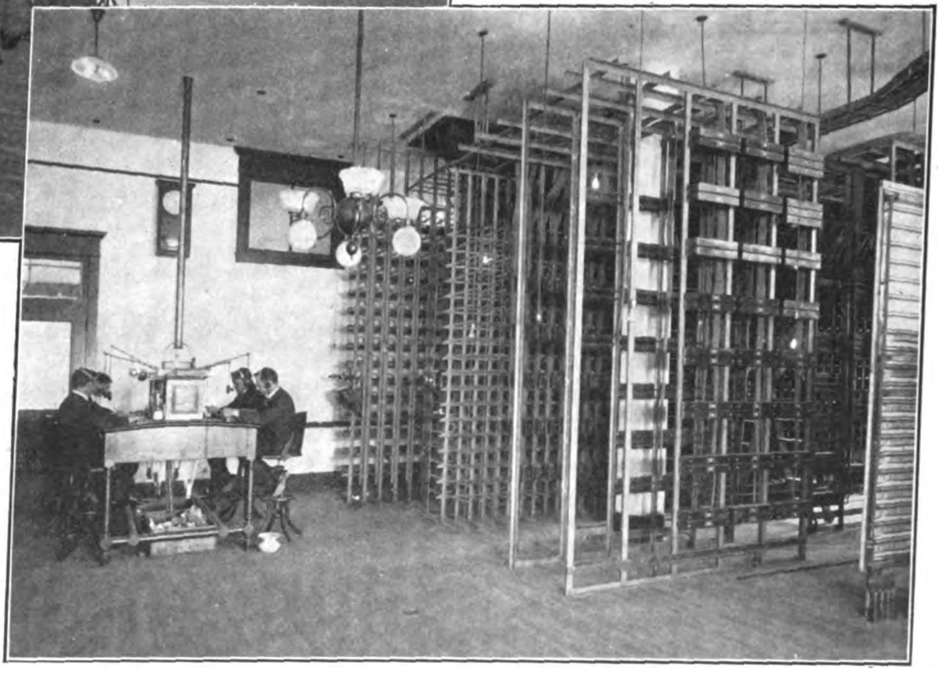

FIG. 3.—DISTRIBUTING FRAMES AND RELAY RACK.

The company's territory comprises the city of Chicago and seven surrounding counties in the State of Illinois and two in Indiana, as will be seen from the accompanying map. This covers an area of some 5500 square miles. In these are included the towns of Elgin, Joliet, Aurora and Evanston, each of which has a population of 20,000 or over. Elgin has an exchange with nearly two thousand subscribers. In Oak Park, a suburb of Chicago, the development has been excellent, 9.4 per cent. of the population having a telephone. There are in all 115 exchanges and 90 toll stations. Fourteen of these exchanges are housed in the company's own buildings. The farming community within the same district has also furnished a large number of subscribers, there being over 2800 of these. The instruments are all of the long distance type and metallic circuits are exclusively employed. The company owns all toll lines radiating from Chicago to the various points in the district and connects with the long distance lines of the American Telephone & Telegraph Company at Chicago, Joliet and Waukegan, Illinois, and Hammond, Indiana. Independent exchanges have been installed at various points; but these have helped rather than retarded growth.

The rates which are being charged in the various exchanges outside of Chicago are $48 for business and $36 for residence telephones, single lines, $36 and $24, respectively, for two-party, $24 and $18 for four-party, and $12 for ten-party lines, which, however, are confined to residences exclusively. A flat rate of $18 is charged for each telephone in rural service where two or more subscribers are connected in each mile of line. Toll rates are based on the air line distance or railway mileage between any two points. This in no case is greater than 25 cents for a three-minute conversation, except to Lake Geneva and Kenosha, to which the rate is 50 cents.

The growth in the city of Chicago has been more remarkable even than in the surrounding territory. The measured service or pay-as-you-go plan probably more than any other factor, has served to popularize the telephone. At present there are 14 exchanges, all of which, with the exception of two in downtown office buildings, are housed in the company's own buildings. At the beginning of the past month there were over 73,000 telephones connected with the city exchanges. In addition there are four suburban exchanges within the corporate limits of the city. The popularity of the telephone is attested by the fact that more than 24,000 instruments are installed in private residences. More than 15,000 telephones are connected with the various private exchanges in the city. In fact, the largest private exchange in the country is located in the city, this having 300 telephones and requiring the service of twelve operators, all outgoing calls being made on the basis of a charge of a nickel. A telephone has been installed in each one of the rooms in the various hotels. The growth has amounted to nearly 5000 telephones in two years.

As already stated, a wide range of rates has been adopted. For unlimited service, including the use of all metallic circuits and long distance telephones, on direct lines, the charge is $175 per annum for business and $100 for residence connections. Two party and four-party line connections are $75 and $60, respectively. In the case of measured service, the charge for direct lines is at the rate of $75 per annum and up, according to the number of calls contracted for. In the nickel service, in which all calls are paid for at the rate of five cents each, the following guarantees are required; 30 cents a day for direct lines, 20 cents for two-party, 10 cents for four-party, 10 cents for business ten-party and five cents for residence ten-party lines.

The increasing growth of the business recently necessitated the installation of a new station known as the Douglas exchange, which was opened for public use on the 19th of September. This embodies in its design the most approved practice of the company. All features in the design of the apparatus, which might be conducive to unsatisfactory service, have been eliminated as much as possible. Likewise the operations to be performed by the operators have been reduced to the smallest number. This naturally tends to reduce operating and maintenance costs, a not undesirable feature in any case. The Douglas exchange contains the general offices for the Southern Division of the City of Chicago, which includes the

Douglas, South, Canal and Yards exchanges. Collections, contracts, installations and maintenance of the lines for the division, are attended to from this office.

The building is a two-story brick structure 48 feet 6 inches by 97 feet. The first story is faced with stone, and the second with yellow pressed brick. All desirable features, as large window areas, an approved heating and ventilating system, etc., have been incorporated in the design. The basement is devoted to the cable plant, the heating system, and also contains the storage battery. The first floor contains the district offices, the power plant and the distributing frames. The second floor contains the operators' quarters and the switchboards. The building is lighted by electric light throughout, but combination fixtures are installed so that gas can be used whenever necessary. The switchboards are lighted by incandescent lamps placed in troughs in such a manner as to throw the greatest amount of light on the multiples and place the answering jacks in a partial shadow.

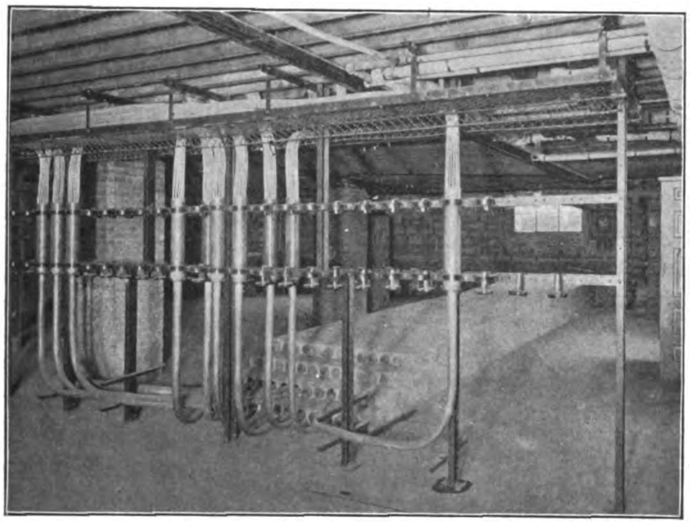

FIG. 4.—CONDUIT AND CABLES IN BASEMENT OF EXCHANGE.

As will be seen from Fig. 4, the conduit system is brought bodily into the basement from a manhole located in front of the exchange. The conduit is of standard construction, Camp tile being used. Four tiers of twelve ducts each are carried to the cable distributing frame, each successive tier projecting beyond the upper one to permit of the cables being readily swung to the rack. Eighteen of the ducts terminate at the inside face of the basement wall, to permit of future extensions being readily made. The cable distributing rack is built of 6-inch channel vertical and horizontal crosspieces which carry a special clamp on which the lower part of the pothead is seated. The latter are sealed entirely with lead where the smaller cables emerge. These are twenty-pair leaded cables and are carried in an iron trough, suspended partly from the ceiling and partly from the frame, to the desired point before passing through the floor to the cable side of the main distributing frame. With the exception of two 300-pair cables, which formerly passed the location of the present exchange, 400-pair cables are used exclusively, of which there are eleven.

On the first floor are located the main and intermediate distributing frames, the subscriber and trunk board relay racks, the fuse boards and the subscriber and trunk board coil racks. The lines from the 20-pair cables coming up from the basement, are brought to the cable terminal blocks in the usual manner. In fact, this part of the equipment is built according to standard Bell practice. The main distributing frame has 31 verticals, each having 15 arms. Although all of the lines entering the building are underground, nevertheless the distribution is mainly overhead and most of the circuits, as a consequence, are protected by lightning arresters. The intermediate distributing frame has 35 verticals, with 19 arms each. From this the three-wire circuits are carried in 20-circuit cables to the subscribers' multiple and answering jacks on the floor above. Back of the intermediate frame are the relay racks, further on are the combination coil racks and fuse boards. All cabling throughout the exchange is run in 10, 20 and 50-pair or tripled flat cables.

There is a marble fuse board for the subscriber board and another for the trunk board. There is a fuse for each pair of operator's cords marked in such a manner as to be readily identified. There are also on the boards for each operator's position, three fuses for line signal lamps, two for the supervisory lamps and one for the operator's transmitter circuit. Each subscriber's circuit is thus protected when making a call through the operator's cord, while additional protection is given by four supervisory-lamp fuses installed on the board for each position. The fuses are arranged so that when one blows, a spring makes contact with a third bus-bar, thus completing a new circuit, lighting a signal lamp at the middle of the row and ringing a bell to call the attention of the trouble man.

The power plant is located on the first floor in the same room with the distributing frames, etc. It consists of two direct connected charging sets, one capable of generating 250 amperes and the other 165 amperes at 30 volts. The generators are direct connected to 220-volt direct-current motors, but should this source of power fail, a 15-h.p. Nash gas engine, which is held in reserve, can be used. The connecting coupling is so designed that the leather disc can be taken out and a flange pulley put in its place and fastened to either machine. This makes it possible to drive either generator from either motor or from the gas engine. One charging set only is on slide rails. There are two ringing generators provided, one of which ordinarily runs from the Edison 220-volt circuit and the other from the office storage battery. Each machine is provided with busy signal and trouble tone attachments besides the regular alternating and party line ringing features.

The power board is of 1¼-inch Italian marble and carries all the necessary rheostats, starting boxes, switches and fuses for the various machines. The instruments provided are a Weston ammeter with shunts to measure the charging and the discharge current, and a Weston voltmeter capable of measuring the bus-bar voltage as well as that of the individual cells of the storage battery. A reverse current and overload circuit breaker is installed in the circuit between the machines and the battery. The power board is enclosed in a ma-

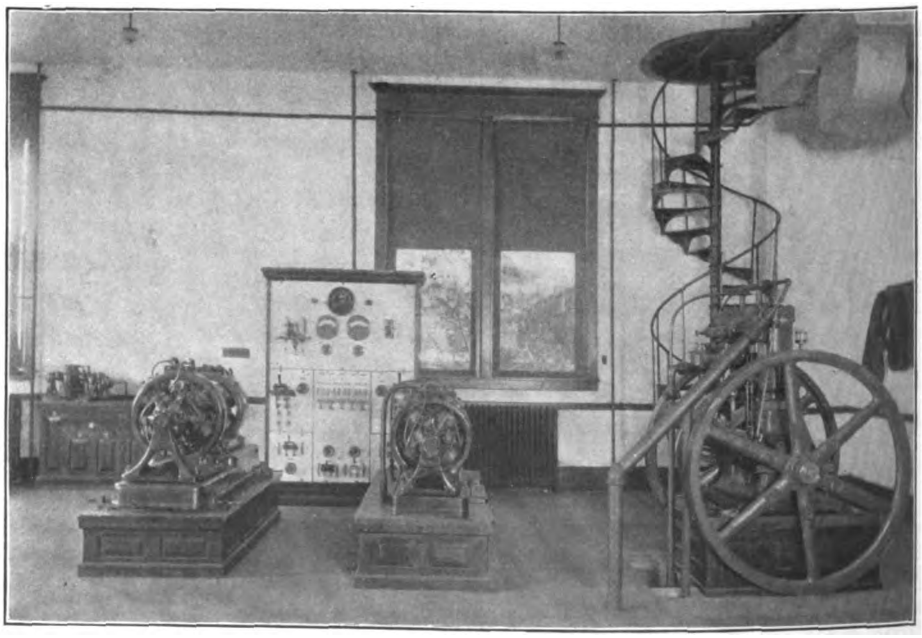

FIG. 5.—GENERATING EQUIPMENT AND SWITCHBOARD.

hogany cabinet and presents a neat and compact appearance.

The storage battery is located in a small room in the basement. This is ventilated by two special flues built into the walls of the building. It consists of eleven chloride cells made by the Electric Storage Battery Company. At present there are seventeen plates, but provision has been made for increasing this to 25. The normal rate of discharge at the 8-hour rate is 160 amperes. The cells are set upon wooden pedestals with the usual insulators.

On the first floor is located a four-position trouble desk, which is connected with the monitor's desk in the operating room by means of a brass ticket chute. All reports of trouble which reach the manager's office are ticketed and sent to the trouble desk through this chute. Another and more direct means of reporting trouble to the desk is in operation and will be taken up later. Each position of the desk is equipped with a Weston milli-ammeter and voltmeter and is provided with the necessary keys and circuits to make very rapid and accurate tests for trouble on the various lines.

That part of the second floor above the main offices, is devoted to a commodious and well appointed operator's room. Each operator is provided with a metal locker. The tables are supplied with the latest magazines, copies of the various instructions issued by the company, and, what has proved a most helpful aid in raising the standard and efficiency of each operator, a record containing the standing of each one during the previous month. This system, adopted by A. D. Hawk, the manager of the Southern Division, has been more conducive than any other to raising the *esprit de corps* of the entire force, and has been a most valuable aid in the operation of the various exchanges. Light meals are also served here to the operators during working hours, at the company's expense.

The operating room of the exchange is 58 feet long and 46 feet wide. It is well lighted by large windows on three sides, and by skylights. The subscriber's answering switchboard is arranged in the form of a horseshoe around three sides of the room. It is a standard relay, multiple, central-energy, lamp-signal board, and consists of fourteen eight-panel, three-position sections, with a present equipment of 3500 lines. The ultimate capacity of the board will be 9600 lines, divided into 19 sections. Wooden drop curtains are furnished at the back of the several switchboards instead of the usual removable panels, making the relays, resistance coils and other apparatus at the back of the board, easy of access to the repair man.

The subscriber board differs in its general features, in no respect from the others operated in the city by the company, with the exception of the use of multiples on four-party lines, a separate multiple being provided for each one of the subscribers on such a line. The ten-party lines are multipled, but restricted to the ten-party line trunk board. On the latter each station is given a separate multiple as in the case of the four-party lines.

The general features of the entire equipment follow standard Bell practice. In front of each operator of the subscriber board there are 17 pairs of cords, of which 15 at present are equipped with the necessary ringing and listening keys, and a supervisor's signal on each cord. Cords having steel instead of the usual brass or copper conductors, are used to reduce the wear and tear to a minimum.

In addition to the regular equipment, the cords in 33 positions are equipped with coin-collecting keys. The number of answering jacks varies from 60 to 160 per operator, depending, of course, upon the class of subscribers served. The present equipment of the outcalling circuits is 30, whereas the ultimate capacity will be double that given. The usual out-trunk multiple for trunk lines to other exchanges, is employed.

All positions in the office are equipped with a breast plate transmitter, this being hung from the operator's neck by a band. A most excellent sanitary provision is that each operator is provided with a transmitter and receiver for her exclusive use. These are connected to the switchboard through suitable plugs and cords.

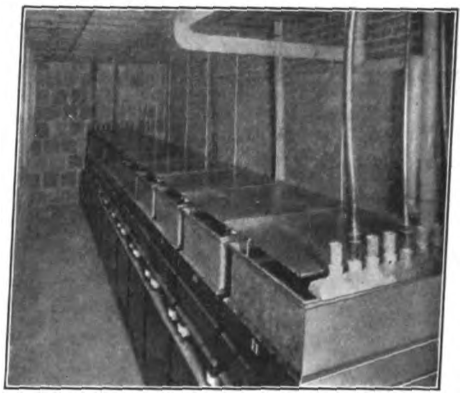

FIG. 6.—STORAGE BATTERY.

The incoming trunk board embodies a new system of incoming trunk lines, whereby it is possible to operate 40 trunk lines per position, as compared with 25, which has been the usual practice. The most important feature of this circuit is the absence of any keys. A special relay is placed in the circuit of certain lines and this, in connection with the relays on the incoming trunk lines, automatically selects the proper generator for ringing a subscriber's bell. The trunks have the usual guard and supervisory signals. The circuit is also so arranged that it is impossible for any operator to receive a shock from the premature placing of the ringing generator on the cord circuit.

This new type of incoming trunk board, which is the first of its kind in service, has many valuable features as compared with the old type. The keyless trunk greatly aids in solving the problem of efficient and economical service. It is efficient because there is less liability of the trunk not ringing than with the key trunks. There is much less liability of cut-offs, as operators have no keys in front of them with talking contacts. These talking contacts, which are easily opened by the slightest depression of the key, cause a bang in the ear and a temporary break in the conversation. It is economical because the trunk operator can handle a great many more connections hourly, a good trunk operator's maximum being controlled by the way the subscriber operators give their orders. A good trunk operator would put up 800 connections in an hour easily if the order wires could stand the load. The keyless trunk, moreover, starts the ringing of the called subscriber's bell the instant it is put up, thereby saving the time required to lock the key on a key trunk. This small saving alone, not only decreases the average subscriber's answering, but makes it possible to add additional completed messages to each trunk line every 24 hours, thus causing a considerable saving in trunk lines from office to office. This board is also equipped with individual transmitters and receivers.

The incoming trunk board for the ten-party lines, is provided only with the multiples of the ten-party lines. Each subscriber has a separate jack, which reduces the number of operator's errors to a minimum as compared to the ten-party line with a single multiple jack. Another valuable feature of individual jacks for each subscriber's station on party lines, is that a subscriber can move anywhere in the office district and retain his own number, the change being made at the intermediate frame. At present, all calls for the ten-party line trunk board are local trunked from the regular trunk board, except calls from the Douglas office, which are local trunked from the subscriber board.

The advisability of bringing direct trunk lines from the various exchanges directly to the ten-party line trunk board, is now being considered. Each position is equipped with 15 pairs of cord with a regular listening key and a temporary manual ringing key. The company is, however, developing an automatic ringing key, which will give the proper code ringing on the 10-party lines.

A special test is provided upon the party-line circuits to be used when one subscriber calls another on the same party line, who is busy. Upon testing on such a line, the operator immediately receives a busy test, different in tone from the ordinary busy signal. This signal is given the operator automatically by the action of a special relay, and upon her hearing it, she tells the calling subscriber to hang up his receiver until she calls the person desired. When the call has been made, the subscriber may take down his receiver and proceed with the conversation after the necessary nickel has been deposited and cashed. All the 10-party lines have nickel service.

The operating room is divided into five supervisors' divisions, each one being presided over by a supervisor, who is held directly responsible to the chief operator for all service complaints and the conduct of the operators in her division. In the nickel work, there are six operators to each supervisor, in flat rate work, nine operators, and in trunk and ten-party line trunk works, six operators each. Each supervisor is relieved in turn by a relief supervisor, and at no time between the hours of 8 A. M. and 10 P. M. are divisions permitted to be without a supervisor for a single moment.

Each operator has a locking key placed in the panel of the board in front of her, which she locks when she wishes to communicate with her supervisor. The locking of this key pulls up a relay and lights a small lamp placed at the top of the board, which in turn starts a buzzer located in the center of the supervisor's division. The latter, on hearing the buzzer, immediately looks for the lamp and responds to that operator. In responding to the operator's call, the operator gives the supervisor what message she has without turning around. If it is a subscriber making a complaint, the supervisor, who goes equipped with breastplate transmitter, head telephone and plug, immediately inserts the latter over the connecting cord, the answering cord being in the subscriber's answering jack. She answers the subscriber with the phrase, "This is Douglas manager's office," and attends to his wants.

This exchange is provided with three overflow positions to equalize the load during the busy hours from 9 to 11 A. M. and from 6:30 to 8:30 P. M. A number of busy lines are selected in each position on which traffic is too heavy during the busy hours, and jumpered on the intermediate board by means of four wires, the ring, the tip, the sleeve, and the lamp wire, to the answering jacks in a position previously selected for the overflows. The relays in this overflow position are disconnected. In the regular position a line so put on the overflow position is designated from the others by a blue opal. When the overflow position is put in service the supervisor tells the operators in the positions where these blue opals appear, not to answer those lines. This order remains in effect as long as the overflow position is kept in service. After the operator is taken out of the overflow position, calls are then answered in the original position. On a line connected up on the overflow, a subscriber on taking his receiver from the hook, lights the lamp both in the originating and the overflow positions. It will be readily seen that these overflow positions help to reduce the cost of operating.

Another plan recently introduced in Chicago provides for positions equipped for sick lines. These are on the subscriber board, and are known as the hospital positions. When a line is out of order it is referred to the hospital operators, who are accessible to the multiple, which bridges in each subscriber and trunk position. An operator, on finding that a line is out of order, notifies the hospital operator over the call circuit. The hospital operator picks it up in the multiple on one of her cords, the shank of which is connected with the howler greatly reduced, which is in series with the battery. This pulls up the subscriber's cut-off relay and puts a light musical noise on the shank of the jack, the former being known among the operators as a tone test. The hospital operator then makes a note of the case on a form specially provided for the hospital operator, showing the line that is up, the time put up, and the time referred to the repair department. She then refers the trouble to the trouble desk, over a call circuit. Subscriber and trunk operators on getting the tone test on any line, connect the calling party over local trunks, which are multipled throughout the subscriber and trunk boards, and terminate on lamps and jacks in front of the hospital operator. The hospital operator in answering calls over these local trunks, uses the phrase, "What number are you calling, please." On receiving the calling party's order, she attempts to raise the calling party, whose line is out of order, and if unable to do so, tells the calling party that ——— is out of order. Quite a few connections are completed in this manner. The Douglas exchange is equipped with one hospital position and 200 auxiliary cords, to be used during storm troubles.

Each subscriber's board position is equipped with a special pair of cords which are used to plug subscribers, complaining of trouble on their line or instruments, direct to the trouble desk. It is thus possible to give immediate attention to all complaints and the line and instruments furthermore, are tested with the person making the complaint. This, of course, as will be readily seen, makes a most satisfactory arrangement for taking care of complaints.

This exchange is equipped with one information position. The operator in this position being accessible to the multiple, looks up any information which subscribers may wish to obtain. For a telephone that has been taken out, the name and number appearing in the current issue of the directory, the multiple is plugged with a red cork; a dead line or telephone taken out, the number not appearing in the current issue of the telephone directory, the multiple is plugged with a black cork; a line on which the calls are being questioned for any cause, the multiple is plugged with a green cork; a number changed to a different exchange, the multiple is corked, the new exchange and number appearing upon the cork. The trunk operator getting a call for any of the above, plugs the calling party through to the information operator, over local trunks which are multipled throughout the subscriber and trunk boards, and terminate on lamps and jacks in front of the information operator. The subscriber operators send all calls for persons by name or question calls of any character, to the information operator who gives out the desired information.

A double monitor desk is provided with a cabinet and equipped with jacks which are bridged to each subscriber, trunk and ten-party line trunk operators' circuit. Two supervisors can thus, from this desk, supervise operators in different parts of the room without their knowing it. This monitor is kept in constant service from 8 A. M. until 10 P. M. The supervisors listen on each operator in turn 15 minutes, noting the number of calls the operator answers, and the number of errors in phrases, etc., made during the supervision. All errors are then taken up with the operator at fault and charged to her record. A careful record is kept of the errors, showing nature of same, total number of operators supervised, and total number of calls answered during the supervision, for comparison from month to month.

The operating room is in direct charge of the chief operator who is directly responsible to the manager for the service and the conduct of the operators and supervisors. The chief operator and her supervisors, in turn, make 16 daily talking tests from an instrument back of the switchboards, especially equipped for this work. The equipment of this instrument consists of Baird dime and nickel automatic boxes, a key, one side of which terminates on a cord in a subscriber position, the other side of the key terminating on a test cord in a ten-party line trunk position, two calling circuits, one to a trunk position and one to a ten-party line trunk position in which the test cords terminate. The supervisor, in making a test, orders up the test cord on a subscriber's line previously selected, which falls in a position occupied by an operator whom the supervisor wishes to test on. This gives the same test results as could be obtained if the supervisor were actually at the subscriber's station. The supervisor, provided with a stop watch, in making these calls, notes the time on a regular form, of the subscriber operator's answers, the ten-party line trunk operator's answers, flash answering and called subscriber's answering. These tests are restricted to 32 calls per day, divided into two groups, 16 of which are made by the day chief operator and her supervisors, and 16 by the evening chief operator and her staff. These tests are scattered throughout the day and evening hours, and are made under all conditions, selecting principally, calls that operators do not often receive, and see how they handle them. A correct record is then made, showing the subscriber operator's answering on call and flash signals and ten-party line trunk answering. The errors are classified, separating the day from the evening work, and a record made for comparison from month to month.

The officers of the Chicago Telephone Company are as follows: Arthur D. Wheeler, president; Byron L. Smith, first vice-president; A. S. Hibbard, second vice-president and general manager; C. E. Mosely, secretary and treasurer. S. J. Larned is the general superintendent in charge of the city exchanges, whereas W. R. Abbott is in charge of all the territory outside of the city of Chicago. J. G. Wray is the engineer. The writer is indebted to Messrs. C. J. Carlsen, assistant engineer, and H. T. Gardner for the data required for the preparation of this article.

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Result of Electrifying Mersey Tunnel.—The Mersey tunnel, in Liverpool, England, shows a 37 per cent increase in traffic since steam was superseded by electricity for haulage. With steam locomotives there were 283 trains a day. Now there are 750 trains a day, operated by electricity. In the first full week of service there were 125,272 local passengers, an increase of 37,619 over the number carried in the last week of steam service.

ALUMINOTHERMICS AND SOME OF ITS APPLICATIONS.

The reduction of metallic oxides by aluminum has long been known as a laboratory curiosity. The ignition of a mixture of powdered aluminum and a metallic oxide resulted in the reduction of the metal of the oxide to the metallic state, by a reaction which was exothermic; that is, when once started it would proceed without the aid of any external heat. Heretofore the starting heat was supplied by placing the crucible in a strongly heated furnace, the resulting reaction being, however, so violent as to be actually dangerous with more than insignificant quantities of the substances.

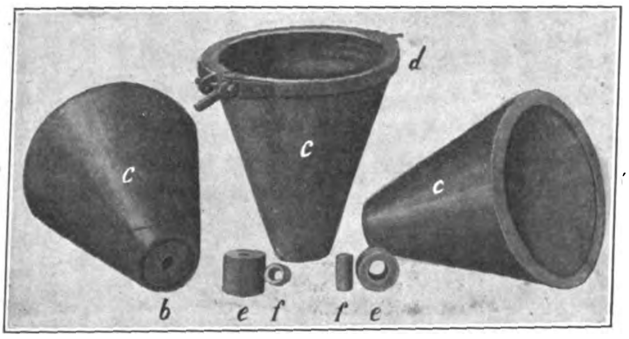


FIG. 1.—CONICAL CRUCIBLES LINED WITH MAGNESIA.

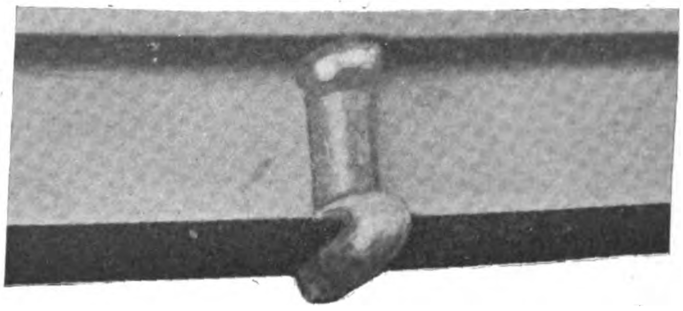


FIG. 2.—SIDE OF RAIL, SHOWING WELD.

It was due to Dr. Hans Goldschmidt, of Essen, Germany, to show how to control this reaction so as to render it capable of industrial applications not only in the line of reducing oxides, but for producing locally and at once an intense heat available for different purposes. In a lecture before the Columbia University Chemical Society on November 13, Dr. Goldschmidt showed that, by producing in a suitable manner the chemical combination of aluminum and oxygen, a temperature is created as intense as that of the electric arc, and on this is based the new science called aluminothermics. Neglecting that portion of the lecture which appertains strictly to metallurgy, the thermit welding process, a description of which follows, constitutes one of the applications of aluminothermics which has received the widest attention and practical application.* Considering the innumerable details connected with the application of so new and practically unknown a force, it is not surprising that only since about a year ago has the process been introduced on a large and commercial scale.

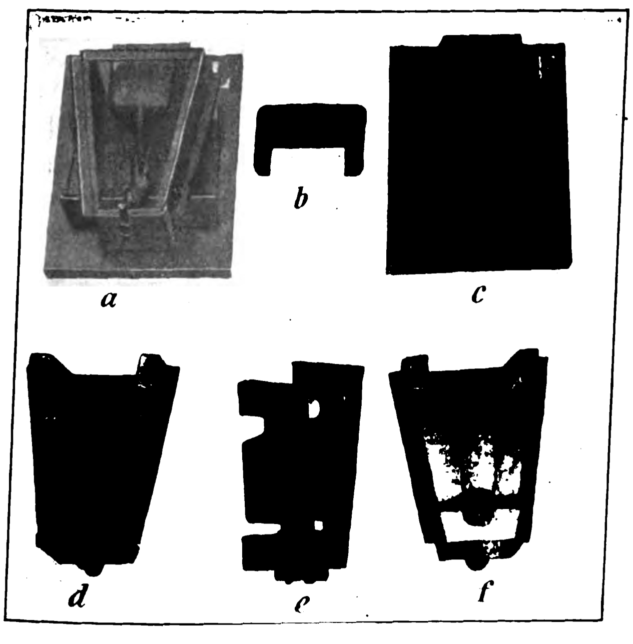


FIG. 4.—WELDING FORMS AND MOULDS.

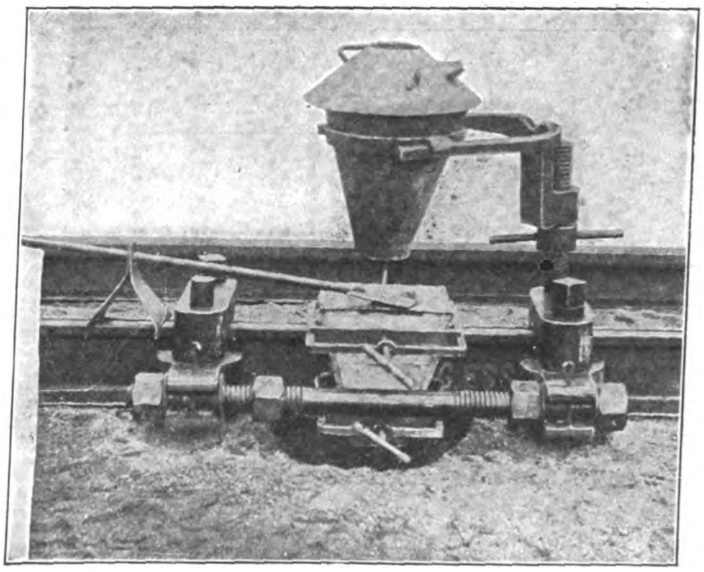


FIG. 3.—COMPLETE WELDING OUTFIT.

The most important of these welding processes is the one by which a continuous rail—a necessity of modern trolley road construction—is simply, cheaply and effectively obtained, it is stated that European authorities recognize its advantages over all its competitors.

The City of Leeds, in England, is using this process over the whole of its track, and an American expert who had occasion to see it employed there, on his own initiative, recommended it for a very important contract at Singapore, where, in consequence, it is being used over a track of twenty-seven miles. Last year 3000 joints were welded, and this year no less than 20,000 joints have been delivered.

What gives this system an advantage over all others is the absence of any bulky equipment; all that is required is a crucible, a mould-box, and in some instances, where a complete butt-weld of the head of the rail is desired, a rail-clamp. All these materials, including the necessary quantity of thermit can easily be moved on a hand truck. Each weld, according to section, requires from fifteen to twenty pounds of thermit.

Even where a rail clamp is used the time employed is less than that necessary for fixing fishplates and copper bonds. The mould is made according to a model specially designed for each section. Its two parts, one on each side, firmly enclose and exactly fit the rail. Certain channels are provided in the mould parts for the thermit iron to run through. The size of these channels varies according to whether slag or iron is to fill the mould, and also in accordance with the requirements of each section. The thermit iron flows round the web and foot of the rail, and, melting them, forms one mass with them. The liquid slag which follows the metal is diverted to the top of the rail and brings the latter to welding heat. The whole section is thus heated equally and the rail ends will not buckle. The forms and moulds are shown in Fig. 3. Here *a* is a model for the lip side with mould shell; *b*, appliance used when ramming the sand in; *c*, model for tread side; *d*, finished half of mould for lip side; *e*, half of mould shell for tread side; *f*, finished half of mould for tread side.

The weld can be made with or without rail clamps. In the former case the rail ends are butted together by tightening the screw two or three minutes after the run. A slight and very short upset will be produced at the joint, which can easily be removed. The simplest way has been found to chisel it off, and one man can even out twenty-five joints in a day in this manner. By using the rail clamps a perfect butt weld is obtained. The rigidity of the joint is particularly great. Under hydraulic pressure the break occurs outside the welded zone, as with the iron shoe welded on to the section the joint is really stronger than the rail.

The use of the rail clamps is, however, by no means obligatory. Without them the work is still further simplified, as the time necessary for adjusting the heavy clamps and for chiselling off the up-set is saved. It has been found by practical experience that the weld without clamps is quite sufficient, and of late clamps have been used less and less. The first application of the weld without clamps was made more than two years ago in the town of Brunswick, Germany, and the town has continued to follow this plan ever since. Nearly all of the work done in France and Italy has been performed without clamps, and altogether this mode has been tried with several thousand joints and given satisfaction. The use of clamps is based chiefly on theoretical considerations. Even a butt-weld can be obtained without clamps, especially if the rails are already imbedded. At Barmen, Germany, such work was done very successfully, the old fishplates being taken off and the ends of the rails raised slightly by means of a crowbar and a shim firmly wedged in between; in this case the shim is welded into the head of the rail.

When welding new rails not yet imbedded, the use of rail clamps can be obviated by firmly wedging up the rail from the next succeeding joint. The time consumed per joint, when working without clamps, is about three-quarters of an hour for one man, but trained squads of four men, including the foreman, do not consume so much time. At $1.50 per day the wage item of cost is ten cents per joint. The use of clamps doubles this amount, but all other labor connected with welding remains the same, whether clamps are used or not. The molds are made in two parts, and may be made either on a large scale by manufacturers of refractory earthenware or by the trolley companies themselves. In the latter case they are made by ramming an ordinary mixture of sand and loam into a sheet-iron case, which is afterward dried at a temperature of about 100 deg. C. The mold, which costs only a few cents, is screwed onto the rail and the rims touching the rail are carefully smeared with clay. Before the molds are applied, however, the rail ends are cleaned of dirt and just with a wire brush and slightly warmed. In case the tops of the rails are to be butt-welded, the section has to be filed. This is all the preparatory work necessary, although a true alignment of the rail is, of course, indispensable. It is evident that none of this work demands special training, the ordinary laborers of the trolley company being able to perform it. A certain supervision, to see that it is carefully done, is a matter of course. In case of wet weather, the protection of a few planks is desirable to prevent the mold and thermit becoming wet. The only remaining appliance necessary for thermit welding is the crucible. This consists of a sheet iron mantle lined with magnesia. It is of simple construction, the lining being introduced by ramming it around a cone which is suspended in the middle of the mantle. The bottom is formed by a hard magnesia stone provided with an exchangeable outlet, which will stand nine to ten runs. The crucible with the cone in it is placed in the furnace for only two hours and finally brought to glow heat. It is then ready for use. Fig. 1. shows the crucibles lined with magnesia, in which *b* is the flow hole, *c*, sheet-iron shell; *d*, protecting ring; *e*, large magnesia stone; *f*, small magnesia stone (thimble). Trolley lines which have adopted the system on a large scale make their own crucibles. Crucibles will stand about twenty-five reactions, and the wear and tear will, therefore, amount to only a few cents per joint. Every section, according to its weight and according to its different dimensions requires different quantities of thermit, the composition of which has also to be regulated for each separate case. Although sections generally in use in this country are higher than the average European ones, the less width counterbalances in a certain degree the height, and on average the quantity of thermit required will be about the same in both countries. It is supplied in small bags containing the exact weight which is needed to effect the weld. These are called welding portions. The companies who make their own crucibles and molds will, therefore, have to pay freight only on the welding portions. As these weigh about twenty pounds gross, the freight is, of course, considerably less than that on fishplates and bolts. The Essen Works have a plant to supply over 500 welding portions daily.

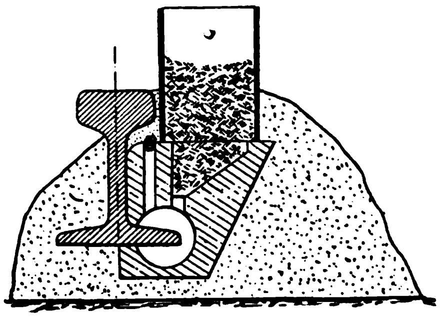


FIG. 5.—ARRANGEMENT FOR WELDING THIRD RAIL.

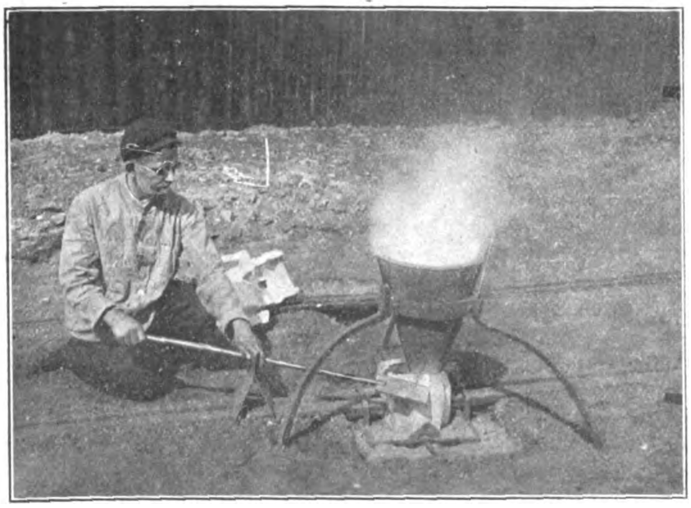


FIG. 6.—REWELDING WITHOUT CLAMPS.

The strength of the weld is about eighty per cent of the strength of the original material. The shoe welded on to the foot of the rail not only makes up for the remaining twenty per cent but materially strengthens the rail at the joint. The head does not get softer, although it is brought to welding heat; the reason being that the operation takes place without the air having access to it. Test rods cut out of rails brought to welding heat with thermit prove this contention. Tensile strength and elasticity have not suffered. Three years' practical experience in over forty towns in Europe confirm these conclusions.

From tests made June 23, 1903, by F. S. MacGregor, permanent way engineer of the Leeds City Tramways, on the strength of thermit joint, the following figures are taken:

Rail supported 5 ft. center to center, test made with 10-in. ram, 2-in. bearing on head of rail.

Up to 28 tons, no deflection and no set, and then 1-64 in.

Up to 30 tons, 1-32 in.
Up to 40 tons, 1-32 in.
Up to 45 tons, 1-64 in.
Up to 50 tons, 3-32 in.
Up to 55 tons, 3-32 in.
Up to 60 tons, ⅛ in.

Test was then stopped, and it was found that there was no permanent set whatever.

Pressure brought on again to 65 tons, still only ⅛ in. deflection; at 68 tons, rail still sound, and at 70 tons, rail broke, but not through the weld.

Hydraulic test, July 7, 1903. Dead load, 5-ft. bearings, 10-in. ram, 2-in. bar on head of rail:

Eighty-five tons, 3-16 in. set.
Ninety tons, ¼ in. set.
Ninety-five tons, ½ in. and slight fracture.

Thermit welded joint tested to dead load as above:

Up to 60 tons no permanent deflection.
Safe dead load at 68 tons.
Seventy tons fractured at side of the weld, the welded portion remaining intact.

Fish and sole-plate joint. Fish-plates, 62 lbs. per pair, 2 ft. long, six 1-in. bolts; sole-plate, 46 lbs., 2 ft. x 8 ins. x ¾ in., 12⅞ bolts.

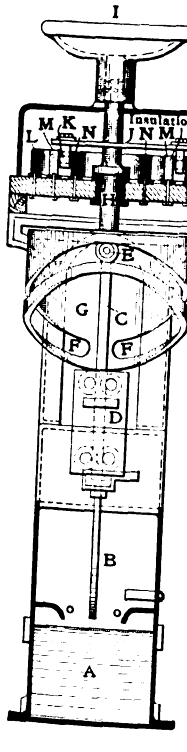
Permanent set at 85 tons, ¼ in.
Permanent set at 90 tons, ⅞ in.
Fractured at 102 tons.

The so-called third rail is also welded by this means. The skin resistance of copper bonds increases with time, and frequent repairs are necessitated thereby; but welding obviates these repairs, and may be done in two ways. The first is identical with the one already described, but without the use of clamps. The second consists in welding a small bridge of thermit iron between the feet on one side of the rail. Both are in use on a large scale. In this case the crucible is superfluous. The welding portion, of about 3 lbs., is placed directly into the upper part of the mold, which is prolonged by a piece of gas pipe.

Fig. 5 shows the third rail and the mold to the right. A tube is placed above the mold and filled with thermit iron. At the bottom the thermit iron mixture rests on a thin iron plate. When the thermit mixture is ignited this plate melts, and the molten mass flows into the mold and the weld is made.

Abstracts from Foreign Contemporaries

Liquid Resistance Switch.—The London *Engineer* describes a new form of liquid resistance switch, which combines a circuit-breaking and direction-reversing arrangement with a regulating resistance. The switch consists essentially of a tank *A* in its lower part, which contains the resistance liquid. Into this dips a contact plate *B*, which is lowered into or raised out of the liquid by means of the shaft *C* working in a roller-bearing arrangement *D*. The shaft is provided with a roller *E* at its upper end, which works in a slot *F* of peculiar form, made in the cylindrically-shaped portion *G*, which can be revolved by means of the vertical spindle *H* and the hand-wheel *I*. It will be readily seen that owing to the form of the slot *F* the plate *B*, which is shown in its higher position and clear of the liquid, will be lowered if the hand-wheel is revolved either to the right or to the left—these motions determining the direction of rotation of the motor to which the switch is connected. Above the liquid in the tank are curved overhanging plates *O*, whose object is to prevent splashing should the switch be mounted on machinery subject to motion. Underneath the hand-wheel is a box having an insulating base of slate. On this base and concentric with the spindle *H* are three metallic contact rings *L*, *M* and *N*. The inside and outside rings, *L* and *N*, are complete, but the middle ring *M* is broken in two places, as shown in Fig. 3, the space between the two halves of the ring being filled up with an insulating material level with the surface of the metal. Attached to the spindle *H* is a bar *J* of insulating material, having two arms of equal length. This is revolved when the hand-wheel is turned and it carries two contact pieces *K* and *K'*, the first revolving between *L* and *M*. Both contact pieces are provided with a spring, insuring electric contact between those rings which it is desired to connect together. Reference to Fig. 3 will show how this switching arrangement works. The positive main or terminal of the generator supplying current to the motor is connected to the ring *L*, one-half of the ring *M* is connected to one terminal of the motor and the other half to the other terminal, while the ring *N* is connected to the dipping plate *B*; the tank, and hence the liquid, is connected to one terminal of the motor fields, the other field terminal being connected to the negative main. With the contact arms i.. the position shown by the full line in Fig. 3, the ring *L* is in electric contact with the left-hand half of the ring *M*, and the ring *N* is in contact with the right-hand half of *M* by reason of the contact pieces *K* and *K'*. In this position the current from the positive main travels from the ring *L*, through the contact piece *K* to the left-hand half of the ring *M*; from there is goes direct to the left-hand motor brush. The left-hand motor brush is connected, as already mentioned, to the right-hand half of the ring *M*; the current, therefore, flows to this and thence, by the contact piece *K* and the ring *N* to the dipper *B*, the liquid tank and the motor field to the negative main. This disposition of the apparatus would cause the motor to revolve in one direction. If it is desired to reverse the direction of rotation the arm is moved to the position shown by the dotted lines. The direction of the current in the field is the same in either case, the direction of current through the aramture only being changed. The switch is only intended for use with series-wound motors and the electrical circuit is always made and broken on the liquid. A short-circuiting contact is arranged on the side of the tank, with the object it is said of cutting out the liquid resistance and doing away with sparking on the reversing switch contacts.



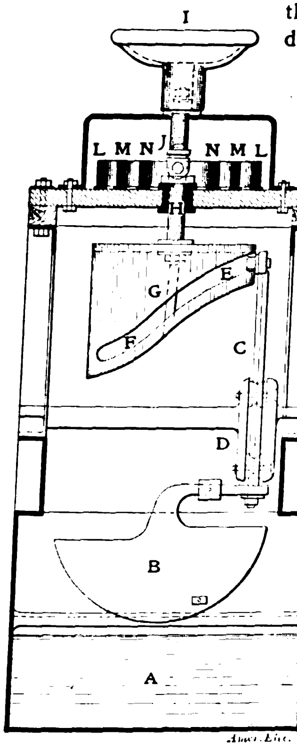


FIG. 1.—LIQUID RESISTANCE SWITCH. FIG. 2.

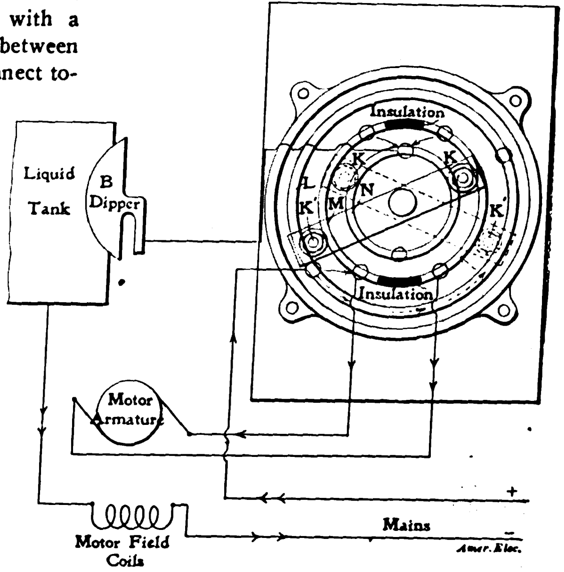


FIG. 3.—RESISTANCE SWITCH CONNECTIONS.

A New Fuel Oil Burner.—Fig. 4 herewith represents a sectional elevation of a new form of burner for liquid fuel, which has been invented by A. E. Johnstone, and is described in a recent number of the London *Engineer*. The chief difference between the burner and others which have been extensively adopted is that the oil is vaporized before coming in direct contact with the jet of steam which impels it into the furnace of the boiler. The construction of the appliance is clearly shown in the illustration, in which *d* is the steam inlet, *m* the oil inlet, and *c* the coil through which the steam passes on its way to the chamber *e* and subsequently, by the discharge *k'*, to the annular space between the hollow sleeve *g* to the spindle *h*. In operation the oil drips into the vaporizer and comes in contact with the steam coil, where it is gasified. The steam traversing the coil passes through to the nozzle, the flared end of the spindle *h* inducing with it the oil vapor round the seating of the sleeve *g*. In fitting the burner to a furnace door, a hole is cut in the latter somewhat larger in diameter than the burner, and in this the appliance is placed. In starting the burner the oil is admitted into the chamber surrounding the coil *c*, when full steam is turned on, the drain cock being kept open to drain the water of condensation. When the oil is sufficiently heated the drain cock is closed and the steam is allowed to pass through the valve draining with the vapor. Tests have been carried out with one of these burners fitted to a Babcock & Wilcox boiler. The heating surface of the boiler is 1065 square feet, the grate area 20 square feet, nominal evapora-

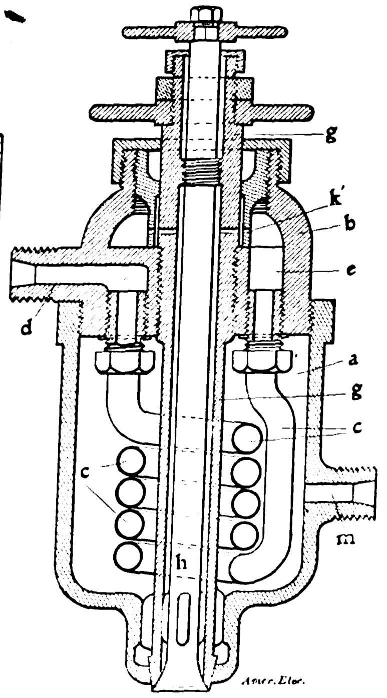


FIG. 4.—FUEL OIL BURNER.

itve capacity of the boiler per hour 3000 pounds, space between top of furnace and bottom tubes 44.5 cubic feet, boiler pressure 150 pounds. The oil used was the cheapest procurable with a specific gravity of 0.925 at 60 degs. Fahr., flash point 185 degs. Fahr., ignition 200 degs. Fahr., and calorific value 19,500 B. T. U. The average actual evaporation of water per pound of oil fuel for four hours was 13.3 pounds, and the average evaporation from and at 212 degs. Fahr. for the same length of time was 15.08 pounds per pound of fuel.

Incandescent Lamp Filament.—As is well known the filament in incandescent lamps gradually diminished in diameter in consequence of the slow volatilization of the carbon. According to the *Elektrotechnische Rundschau,* a German firm introduces into the glass globe certain chemical compounds with a high boiling point; these, under the influence of the temperature in the lamp bulb, slowly give off vapors containing carbon, which is deposited on the filament, thus making up to a large extent for the loss referred to above, and keeping the resistance also the brightness of the lamp more uniform throughout its useful life.

New Graphite Resistance.—R. Hopfelt describes in a recent issue of the *Elektrotechnische Zeitschrift* his experiences of several years in the development of graphite resistances. Figs. 5 to 8 show the forms taken by these resistances. The graphite is in the form of a powder and put into separate rings of iron closed at the ends by iron plates, which are, however, insulated from the rings by mica and asbestos. The iron plates carry the current and also serve to dissipate rapidly the heat generated inside. As many cells as are required can, of course, be connected together in series. If, say a 6-h.p. 220-volt starting resistance, is connected directly to a 220-volt circuit, the current at first is about five amperes, but increases in less than 10 seconds to 35 amperes. Within the next five seconds it increases to over 100 amperes, so that the resistance has fallen from 42 ohms to 6.3 ohms in the first 10 seconds and to 2.2 ohms in the next five seconds. If, however, after the first 10 seconds an additional adjustable resistance is put in series and regulated to maintain a constant current of 35 amperes, the voltage across the graphite resistance will fall from 220 to about 130 volts within the next 10 seconds, and will then remain constant, however long the test be continued.

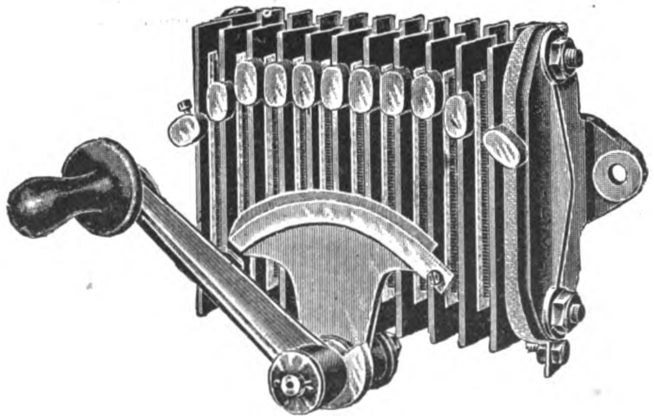


FIG. 5.—GRAPHITE RESISTANCE.

TABLE I.

Amp.	Volt.	Ohm.	Amp.	Volt.	Ohm.
0.1	40	400.0	2.6	127	49.0
0.2	43	215.0	2.8	130	46.5
0.4	54	135.0	2.9	132	45.5
0.8	66	82.5	3.0	135	45.0
1.0	76	76.0	3.4	144	42.5
1.2	84	70.0	4.0	164	41.0
1.6	96	60.0	4.8	183	38.0
1.9	105	55.5	5.5	202	36.8
2.1	113	54.0	6.0	216	36.0
2.3	118	51.3	6.3	221	35.0

Table I shows the result of another experiment. A small resistance consisting of three cells, and which had been in constant use for some time previously, was tested at different currents for quite short periods at a time, an interval of a quarter of a minute was allowed between each reading and the next, so that the resistance remained practically as cool at the end as at the beginning of the test. The resistance was quickly measured in each case by means of a deadbeat ammeter and voltmeter. At .1 ampere the resistance was 400 ohms, whilst at 6.3 amperes it had fallen as low as 35 ohms. It is also clear that the differences between successive readings become smaller the higher the current strength, so that it would seem that the resistance finally becomes independent of the current. After the last reading the current was suddenly reduced to .2 ampere again, and the resistance then measured 213 ohms against 215 ohms when quite cold. The apparatus was then connected direct to a 221-volt circuit, and showed 6.3 amperes again. After five seconds' connection to 221 volts the current had risen to 7.5 amperes and the resistance load fallen from 35 ohms to 29.5 ohms. The current was then once more suddenly reduced to .2 ampere, and the resistance then measured 195 ohms.

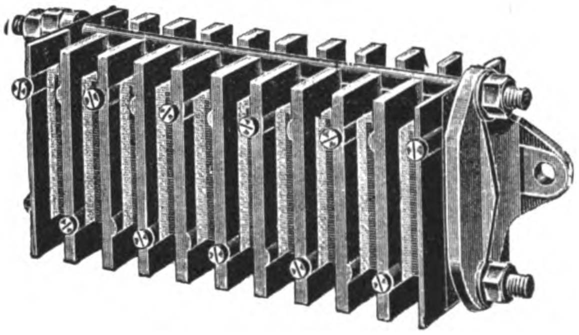


FIG. 6.—GRAPHITE RESISTANCE.

This same test was repeated with 10, 15 and 20 seconds' loading, and showed the following results:

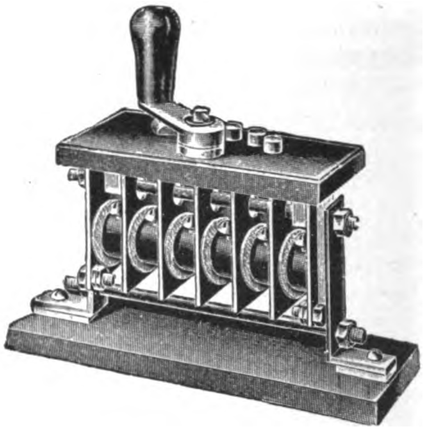


FIG. 7.—GRAPHITE RESISTANCE.

At start.	After 5 seconds.
6.3 amperes, 35 ohms	7.5 amperes, 29.5 ohms.
	.2 amperes, 195 ohms.
	After 10 seconds.
6.3 amperes, 35 ohms	8.8 amperes, 24 ohms.
	.25 amperes, 140 ohms.
	After 15 seconds.
6.4 amperes, 34.5 ohms	12 amperes, 18.4 ohms.
	.35 amperes, 71.5 ohms.
	After 20 seconds.
6.7 amperes, 33 ohms	18 amperes, 12.3 ohms.
	.4 amperes, 37.6 ohms.

An interval of half a minute was allowed between the tests. From the foregoing readings it is clear that after a considerable current has passed the resistance rises considerably even in the first tenth of a second after reducing the current, showing that the resistance is practically dependent on the current strength and not on the heating.

As a further test, various currents passed for sufficient lengths of time for the resistance to become constant. After each test an interval of half a minute was allowed, and the following results were obtained:

At start	5 amperes	171 volts, 34.2 ohms.
After 85 seconds		140 volts, 28 ohms.
At start	8 amperes	165 volts, 20.6 ohms.
After 60 seconds		115 volts, 14.4 ohms
At start	12 amperes	150 volts, 12.5 ohms.
After 50 seconds		96 volts, 8 ohms.
At start	15 amperes	115 volts, 7.7 ohms.
After 40 seconds		70 volts, 4.7 ohms.

These readings show that the higher the current, the shorter the time required for the resistance to become constant. Half a minute after the above tests weak currents of various amounts were passed through

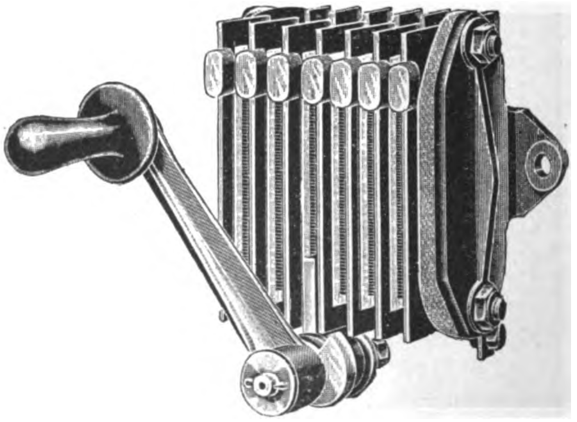


FIG. 8.—GRAPHITE RESISTANCE.

the resistances for about a second, and the resistances then measured showed that, although fairly hot, the original cold figures, especially at the higher currents, were almost repeated. After an interval of five minutes the exact original resistances had been reached once more, although the resistance was not yet quite cold. As a result of these changes of resistance, these regulators can be constructed with comparatively few contacts, and yet motors started with them, it is claimed, will run up more evenly than with the ordinary starting boxes having wire resistance.

SOME RECENT ELECTRICAL PATENTS

Multi-Speed Motor Controller.—It frequently occurs in the operation of motor-driven printing presses and other machinery that it is necessary to run at one or two very low speeds and also at several speeds, somewhere near and including the normal full speed of the apparatus. A familiar means for obtaining speed gradation is the ordinary rheostat or adjustable resistance in the armature circuit, but this is subject to the disadvantage that any variation of the current required in the work circuit will cause a similar variation in the drop of potential within the rheostat and a consequent inverse variation in the e.m.f. actually impressed at the brushes of the motor, producing a change in speed. In order to guard against excessive increase in the speed of a printing-press or similar motor when the rheostat is set for a very low speed, the arrangement illustrated diagrammatically by Fig. 1 herewith has been devised and patented by H. H. Cutler. The motor armature and field winding are indicated at the extreme right of the engraving; the rheostat resistance, 3, is cut in or out of circuit in the usual manner by the swinging arm 2, which, however, has other functions. The diagram shows the apparatus in the "off" position. To start, the arm, 2, is moved clockwise until the insulated contacts 42, 42 rest on the buttons 46 (shown beneath the arm 2 in the engraving) and 47. The insulated contacts are connected electrically, so that when on these buttons they complete a circuit through the winding of the solenoid, 38, in parallel with the motor armature. The regular brushes of the arm, 2, will have previously closed a circuit through the solenoid, 19, and caused this to lift its core, closing the motor circuit at the contacts 9, 9. The motor now runs at the slowest speed, all of the armature resistance being in circuit. The solenoid, 38, though energized, does not lift its core because it is adjusted so that as long as the motor armature runs at slow speed the potential difference at its terminals will be insufficient to raise the core; should the motor speed go beyond the normal while the rheostat arm is in the "slow" position, however, the solenoid, 38, will lift its core and close a circuit, 34, in shunt to the motor armature, shunting current from the armature and thereby reducing the torque so that the speed drops back again. The resistance, 39, is provided for the purpose of adjusting the valve of the current which is shunted from the armature of the motor.

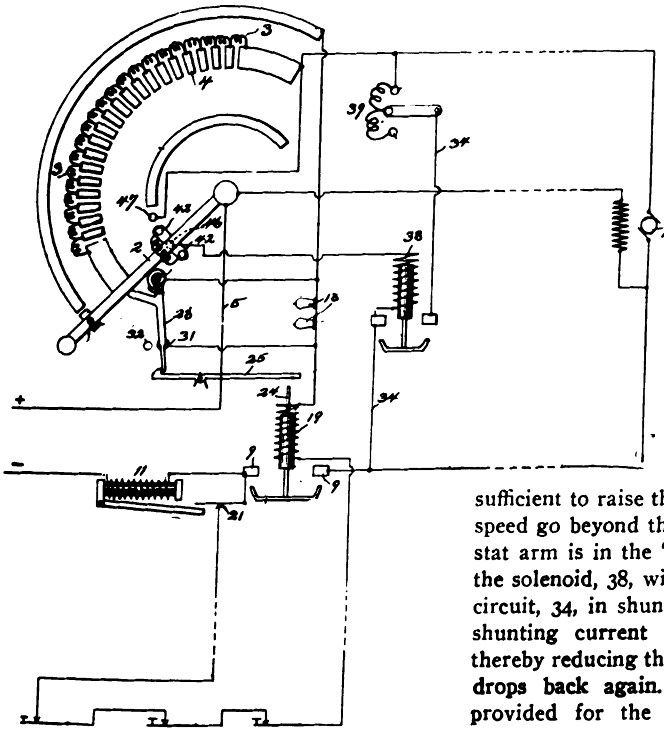


FIG. 1.—MULTI-SPEED CONTROLLER.

When the solenoid, 19, pulls up its core, the projection, 24, strikes the trip, 25, and releases the lever, 28, which is thrown by a spring over to the stop, 32 (the rheostat arm, 2, having been moved away from the "off" position in order to energize the solenoid, 19); this removes a short-circuit around two lamps, 18, in series with the solenoid, 19, so that the latter is considerably weakened, but not sufficiently so to make it drop its core. Should the motor be shut down by pressing any one of the push-buttons, 20, provided at various points around the printing press, the rheostat arm, 2, will be left in whatever position is occupied at the moment of shutting down, no automatic release being employed for obvious reasons; now, if the push-button be released, it will close the exciting circuit of the solenoid, 19, again, and but for the presence of the lamps, 18, in series with the solenoid, the latter would lift its core and close the motor circuit with part or all of the resistance cut out. The solenoid is so weakened by the lamps, however, that it cannot lift the core, which it previously retained in the upper position because the magnetic circuit was more nearly closed than in the lower position. In order to start up, therefore, it is necessary to move the rheostat arm back to the off postion, so that it may reset the lever, 28, on the stop, 31, and thereby short-circuit the lamps, 18. The magnet, 11, is an automatic circuit-breaker magnet, the armature of which opens the switch, 21, when the motor current becomes excessive, and thereby de-energies the solenoid, 19, causing the latter to open the motor supply circuit. Patent No. 743,463.

Intercommunicating Telephone System.—Figs. 2, 3 and 4 illustrate an intercommunicating telephone system patented by T. J. Seely and Charles Hemsing, which embodies the feature of automatically resetting the selective signalling apparatus after a conversation is finished. The system is of the "limited" common battery class; that is to say, a common battery is used for signalling but not for talking, individual batteries at each station being used for the latter duty. Each instrument is provided with as many spring fingers, *a*, *a*, Fig. 2, as there are stations in the system; these are depressed by push-buttons in the familiar manner, as indicated in Fig. 3, which is a sectional elevation of the signalling apparatus. When a finger is depressed and forced against the battery strip, *b*, it raises the hanging edge of a tilting bar, *T*, and passes beyond it; the bar drops back into place after the spring finger has passed, and when the latter is released by the removal of the user's finger from the push-button, it comes back against the rear face

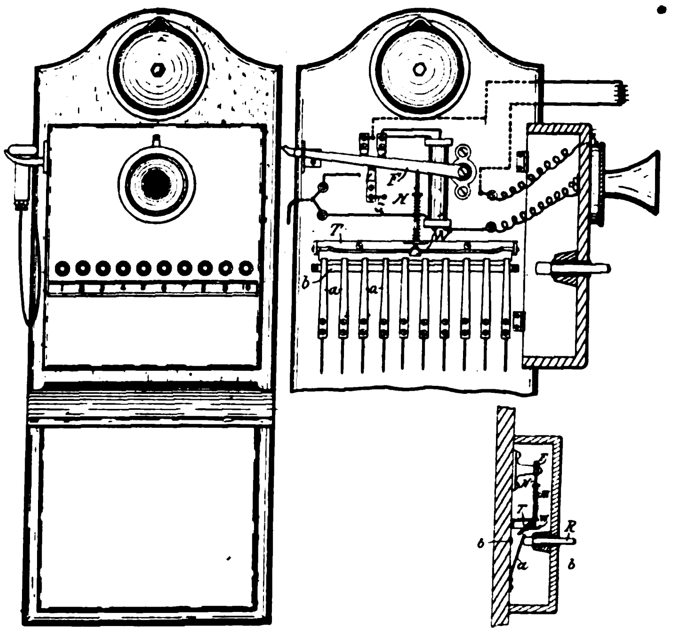


FIG. 2.—INTERCOMMUNICATING TELEPHONE SET.—FIG. 3.

of the tilting bar and remains in contact with it until the bar is again raised by placing the telephone receiver on the hook, the latter in its descent raising the tilting bar through the medium of the plunger, *N*, Figs. 2 and 3, and a lip, *W*, on the upper part of the tilting bar. The tilting bar, *T*, is practically one terminal of the home station in each case, and the fingers, *a*, are connected to the various tilting bars. The operation of the system will be clear upon analyzing the diagram, Fig. 4. This shows the receiver at station *I* off the hook, releasing the tilting bar so that its hanging edge is in the path of the push-button springs. If the button corresponding to one of the other stations be depressed far enough to come into contact with the battery plate, *b*, the bell at the corresponding station will be rung by means of the battery, *E*. Then , upon releasing the push-button, the spring finger will come back against the home tilting bar, connecting that terminal of the home station to the bar of the called station; the other terminals of all the stations are connected to the common return wire, *H*, which also serves as one of the battery wires for signalling when the hook switches are down. Electrical connection between the hook switch and the tilting bar is made by the plunger, *N*, and the lip, *W*, and the backward pressure of the spring finger against the hanging edge of the tilting bar makes this connection extra secure during conversation. Patent No. 744,117.

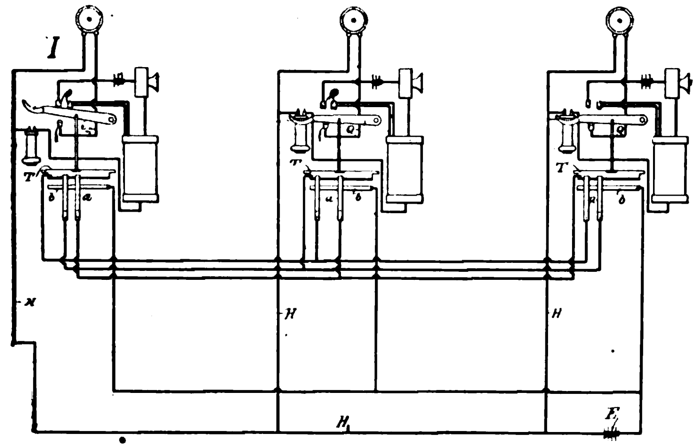


FIG. 4.—DIAGRAM OF CONNECTIONS.

Telephone Repeater.—Fig. 5 illustrates the latest attempt at a telephone repeater, so far as the public records show. It is the invention of Gustavus E. Sundquist, and comprises bipolar telephone receives, 1*a* and 1*b*, having their diaphragms arranged to operate the diaphragms of granular carbon transmitters, 4*a* and 4*b* respectively; together with a three-coil transformer or induction coil, 3, and a battery, 5. One winding of the induction coil is in series with one line, another winding is in series with the other line, and the third winding is in series with the battery and the transmitters, the latter, however, being in parallel with each other. It will be obvious that current variations in one of the lines will induce similar but weaker current impulses in the other line through the medium of the induction coil, and that these will be somewhat chanced by impulses induced simultaneously by the transmitter through the medium of the battery and the third winding on the induction coil. The inventor states that the winding, 2*a*, of the induction coil induces in the winding 2*b* "talking-currents of equal strength with those received," but this, of course, is impossible. It is, moreover, not quite rational to suppose that "sound undulations conveyed by one line may be transmitted to another line with increased volume" by means of this apparatus, assuming that the inventor means "volume" to be synonymous with "power" or "strength." But the arrangement has the merit of ingenuity. Patent No. 743,529.

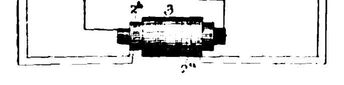


FIG. 5.—TELEPHONE REPEATER.

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NOTES.

Power House Blown Up.—The electric light and power house at Hastings, Colo., was blown up by dynamite on November 10. The explosive not being placed correctly, only a part of the building was destroyed. It is thought that most of the machinery can be repaired. It was reported that the dynamite was placed by the striking miners, but they deny the charge.

The Arkansas City Telephone Exchange of the Missouri & Kansas Telephone Company is being rebuilt. The company is stringing over 15,000 ft. of cable, and everything is being replaced with the latest improved apparatus. This will be one of the company's best exchanges when the work is all completed. The company is also stringing a new toll line from Arkansas City to Maple City, via Silverdale.

A 100-Mile Electric Railway.—An electric railroad, backed by capitalists of Missouri, Boston and New York, is to be built from Mexico, Mo., to Memphis, Tenn., a distance of 100 miles. The road will run from Mexico through Paris, Shelbyville, Shelbine and other important towns between there and Memphis. The track will be of standard gauge, so that the company can handle passenger and freight cars from the steam railroads. The headquarters will be in Mexico, Mo.

The Missouri & Kansas Telephone Company Wins.—Judge Dale has handed down the final decision in the case of the City of Wichita *vs.* Missouri & Kansas Telephone Company, which is to the effect that the company has a right to maintain an exchange and toll lines in the city and that it may construct such new lines as may be deemed necessary in any street or alley, but that the city shall have a right to designate the place where such poles shall be set. This will give the Missouri & Kansas Telephone Company the right to do business in Wellington, Winfield and Arkansas City, where they have been tied up on the same conditions as at Wichita.

A New Theory of Magnetism.—In a paper read before the Cassel Congress of German Naturalists, Mr. Zacharias gives quite novel and somewhat paradoxical ideas as to the nature of magnetical phenomena. According to him, magnetism is due to mechanical phenomena occurring in the ether and attended by a certain more or less high ether vacuum. Mr. Zacharias tries to illustrate the mutual action of a magnetic rod and a magnetic needle by the action of two rotating spheres, one being suspended by a thread, which are found to exert on one another a repulsion in the case of the direction of their rotation being the same, whereas for opposite rotations they are found to attract one another.

Power House and Locomotive Equipment for The Central Railroad.—The New York Central & Hudson River R. R. Co. has placed an order with the General Electric Company for eight turbo-generators of a capacity of 7500 horse-power each. The turbines are to be of the Curtis four-stage vertical type. The generators are to be 25-cycle three-phase machines, generating current at a pressure of 11,000 volts. This is said to be the largest order for steam turbines ever placed, in this country or abroad. The New York Central Company has also placed with the General Electric Company an order for thirty electric locomotives, which are to be of an entirely new design, weighing 85 tons each and having an effective weight on the drivers of 67 tons. Each locomotive will have a capacity of 2200 horse-power, and will be capable of hauling a train of 500 tons at a speed of 60 miles an hour.

American Society of Mechanical Engineers.—The 48th meeting of this organization will be held in New York, December 1 to 4, inclusive. The headquarters for delegates will be at the Society's rooms, No. 12 West Thirty-first Street, and professional sessions will be held there on Tuesday and Friday, December 1 and 4. On Wednesday, December 2, the business session of the Society will be held in Mendelssohn Hall, 113 West Fortieth Street, and on Thursday, December 3, a session will be held in the auditorium of the Stevens Institute of Technology, Hoboken, N. J., after which a luncheon will be served in the Carnegie Laboratory of Engineering at the Institute. Members will be invited to remain after the luncheon and inspect the laboratory, shops and drawing rooms of the Institute. On Thursday evening a reception and conversazione will be held at Sherry's, corner of Forty-fourth Street and Fifth Avenue. The reception will begin at nine o'clock. It is particularly urged that none of the delegates remain away from the reception because the exigencies of travel have made it inconvenient to provide evening dress. The final professional session will be held Friday morning, December 4, and in the afternoon a visit will be made to the works of the De Laval Steam Turbine Company at Trenton, N. J., if a sufficient number of delegates express a desire to take the trip. In addition to the large number of interesting papers, it is expected to have topical discussions of some ten or twelve practical subjects.

Heat Engines and the Problem of Liquid Fuel.—In a paper recently read before the Verein Deutscher Ingenieure, Mr. R. Diesel records the heat utilization shown by the most important types of heat engine according to the latest returns available. From the accompanying table it is inferred that the progress made by each of these types is about the same, being about 30 per cent; the Diesel engine is shown as remaining ahead of the other types. Explosion motors have made advances as high as 50 per cent. by the use of fuels containing water. It is further shown in this paper that such attempts as have been made to use alcohol as fuel in internal combustion engines are devoid of any rational basis. In fact, the cost of operation using spirit for fuel is about 4½ times greater than with cheap paraffin and raw oils.

COMPARATIVE THERMAL EFFICIENCIES OF HEAT ENGINES.

Kind of engine.	Heat units required per I.H.P.	Actual Heat Utilization. Per cent of heat turned into work.
3,000 h.p. steam engine with triple expansion, 180 lbs. boiler pressure, and 314° superheat..	4010	15.7
Power-gas motors	3200	20.0
Spirit motors	1945	32.7
Diesel oil motor	1780	35.7

Some different types of Diesel motors were also discussed by the aid of diagrams, and the problem of liquid fuel was dealt with. The importance of liquid fuel, in Mr. Diesel's opinion, cannot be overrated, such fuel being possibly more widespread over the earth than even coal in its different forms.

Electric Railway Interests at the Exposition.—In view of the growing importance of the electric railway interests of this country, plans are being carried into effect which contemplate a very prominent recognition of the electric railway and electric railway problems at the St. Louis Exposition. The appointment of an Advisory Commission on Electric Railway Tests of the Louisiana Purchase Exposition has just been announced. The Commission is representative of each branch of electric railway activity and will, undoubtedly, receive the support of the entire electrical industry in any plans for the promotion of electric transportation which they may devise. The personnel of the Commission is as follows:—J. G. White, president of J. G. White & Co., New York, chairman; H. H. Vreeland, president of Interurban St. Ry. Co., New York; W. J. Wilgus, vice-president of New York Central & Hudson River R. R., New York; George McCulloch, president of Union Traction Company, of Indiana, Indianapolis, Indiana, and James H. McGraw, president McGraw Publishing Co., New York.

The Commission will act in an advisory capacity in connection with a series of tests on electric railway apparatus to be conducted at the Exposition under the auspices of the Department of Electricity. Prof. W. E. Goldsborough, chief of that department, states that the electric railway test tracks have been laid north of the Transportation Building on the exposition grounds, and represent a practically level clear double track, 1,400 ft. in length. These tracks will connect with the Intramural railway and also the steam railway system serving the grounds. It is said that several important manufacturers have already promised complete equipments for exhibition and test, and the present outlook indicates that the new systems of alternating-current propulsion, as well as the older direct-current system, will be offered for inspection and operation. It is not so much the intention to conduct these tests in a competitive sense as it is to arrange for the accumulation of data which will be valuable in promoting further electric railway undertakings from an engineering standpoint.

Pressure-Temperature Properties of Sulphur Dioxide.— The investigation of the performance of binary heat engines (using steam in one member and sulphur dioxide vapor in another) which has been in progress during the past two or three years has inspired several students of the subject to determine more closely than had hitherto been done the relation between the temperature and the pressure of sulphur dioxide vapor throughout what might be called a "working" range. Probably the latest set of observations made in this country are those recorded herewith. These were made by Mr. D. D. Mohler, a senior in chemical engineering at the Massachusetts Institute of Technology, under the direction of Prof. Edward F. Miller, and the results were published in a paper read by Prof. Miller before the meeting of the American Society of Mechanical Engineers, which is in progress as this issue of the AMERICAN ELECTRICIAN is being prepared for publication. We are indebted to the paper mentioned for the data here presented. The table and chart give, of course, identical data; the tabulated values were taken from the chart (which was 4½ ft. x 11 ft. in the original) after the latter had been plotted from a smaller number of observed values ranging from 68.2 to 211.14 Fahrenheit. The observations of Mr. Mohler approximate remarkably near to those of Regnault through the range covered by Regnault's experiments; below 131° Mr. Mohler's values of pressure are very slightly above those of Regnault, and above 131° they are slightly below, the two curves crossing at 131°.

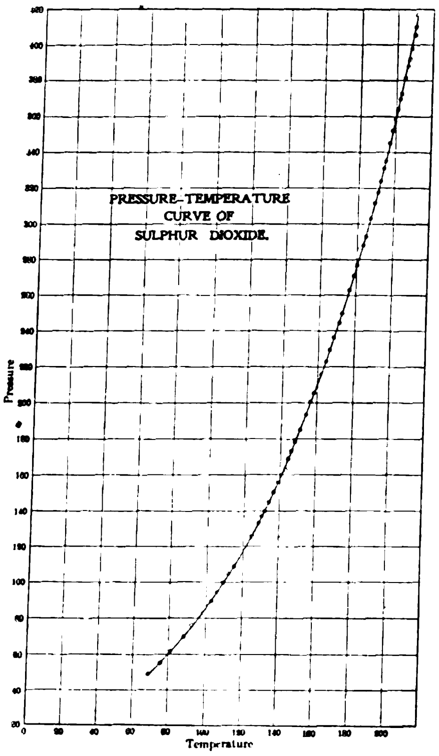

FIG. 1.—SULPHUR DIOXIDE VAPOR CURVE.

TEMPERATURES AND CORRESPONDING PRESSURES OF SATURATED SULPHUR DIOXIDE VAPOR.

Temperature °F.	Pressure Lbs. Absolute.	Temperature °F.	Pressure Lbs. Absolute.	Temperature °F.	Pressure Lbs. Absolute.	Temperature °F.	Pressure Lbs. Absolute.
—39	3.2	24	18.8	87	67.9	150	182.1
—38	3.3	25	19.3	88	69.1	151	184.8
—37	3.4	26	19.7	89	70.3	152	187.4
—36	3.6	27	20.1	90	71.6	153	190.0
—35	3.7	28	20.6	91	72.8	154	192.7
—34	3.8	29	21.0	92	74.1	155	195.4
—33	4.0	30	21.5	93	75.4	156	198.2
—32	4.1	31	22.0	94	76.7	157	201.0
—31	4.2	32	22.5	95	78.0	158	203.8
—30	4.3	33	23.1	96	79.3	159	206.6
—29	4.5	34	23.6	97	80.7	160	209.5
—28	4.7	35	24.2	98	82.1	161	212.4
—27	4.9	36	24.7	99	83.5	162	215.3
—26	5.0	37	25.3	100	84.9	163	218.3
—25	5.1	38	25.9	101	86.3	164	221.4
—24	5.2	39	26.5	102	87.7	165	224.5
—23	5.4	40	27.1	103	89.1	166	227.6
—22	5.5	41	27.7	104	90.6	167	230.7
—21	5.7	42	28.2	105	92.1	168	233.9
—20	5.9	43	28.8	106	93.6	169	237.1
—19	6.0	44	29.4	107	95.1	170	240.3
—18	6.1	45	30.1	108	96.7	171	243.6
—17	6.3	46	30.7	109	98.3	171	246.9
—16	6.5	47	31.4	110	99.9	172	250.2
—15	6.7	48	32.1	111	101.5	174	253.6
—14	6.9	49	32.8	112	103.1	175	257.0
—13	7.1	50	35.5	113	104.7	176	260.5
—12	7.3	51	34.2	114	106.3	177	264.0
—11	7.5	52	34.9	115	108.0	178	267.6
—10	7.8	53	35.6	116	109.7	179	271.2
—9	8.0	54	36.4	117	111.4	180	274.9
—8	8.3	55	37.1	118	113.2	181	278.6
—7	8.5	56	37.9	119	115.0	182	282.4
—6	8.7	57	38.7	120	116.8	183	286.3
—5	9.0	58	39.4	121	118.6	184	290.2
—4	9.3	59	40.2	122	120.5	185	294.2
—3	9.5	60	41.0	123	122.4	186	298.2
—2	9.7	61	41.8	124	124.3	187	302.2
—1	10.0	62	42.6	125	126.2	188	306.2
0	10.3	63	43.4	126	128.1	189	310.2
1	10.6	64	44.3	127	130.0	190	314.3
2	10.9	65	45.2	128	131.9	191	318.4
3	11.2	66	46.1	129	133.9	192	322.6
4	11.5	67	47.0	130	135.9	193	326.8
5	11.8	68	47.9	131	137.9	194	331.1
6	12.1	69	48.8	132	139.9	195	335.4
7	12.4	70	49.7	133	141.9	196	339.8
8	12.7	71	50.6	134	143.9	197	344.2
9	13.1	72	51.6	135	146.0	198	348.7
10	13.4	73	52.6	136	148.2	199	353.2
11	13.7	74	53.6	137	150.5	200	357.7
12	14.0	75	54.6	138	152.8	201	362.3
13	14.4	76	55.6	139	155.2	202	367.0
14	14.8	77	56.6	140	157.6	203	371.8
15	15.2	78	57.7	141	159.9	204	376.7
16	15.6	79	58.8	142	162.3	205	381.6
17	16.0	80	59.9	143	164.7	206	386.6
18	16.4	81	61.0	144	167.1	207	391.7
19	16.8	82	62.1	145	169.5	208	396.7
20	17.2	83	63.2	146	171.9	209	401.8
21	17.6	84	64.3	147	174.4	210	407.0
22	18.0	85	65.5	148	176.9	211	412.5
23	18.4	86	66.7	149	179.5	212	418.0

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CONTENTS.

Power Plant of the Meridan Electric Light Company 575
The Development of Small Water-Powers, by Louis Bell, Ph. D. 583
Electric Traction on Canals 584
The New Douglas Exchange of the Chicago Telephone Company 586
Aluminothermics and Some of its Applications 591
Abstracts from Foreign Contemporaries 593
Some Recent Electrical Patents 595
Notes 596
Editorial 598
Construction of a Magnetic Vane Voltmeter or Ammeter, by J. C. Brocksmith 600
Central Energy Intercommunicating Telephone System, by H. S. Webb 602
Indicator Diagrams, by C. L. Hubbard 603
A Magneto Switchboard for Small Exchanges, by A. D. O'Brien 604
The Three Voltmeter Method of Measuring Alternating-Current Power 606
The Hot Water Meter for Boiler Evaporative Tests, by J. A. Drew 607
Lessons in Practical Electricity 608
Letters on Practical Subjects 610
Queries and Answers 611
Automatic Block Signal System for Street Railways 612
•Power Equipment in the Mexican Central Railway Shops 616
The New Worthington Plant 616
New Apparatus and Appliances 617
New Books 620
Obituary ..... Adv. 55
Personal ..... Adv. 55
Trade Publications ..... Adv. 55
Business News ..... Adv. 55

Prime Movers for Electric Stations.

That the tendency toward electric generating stations of large outputs has had a conspicuous influence upon the development of prime movers of what might be termed "radical" types for lack of a more appropriate adjective, is evident on all sides. The "large" station of six or eight years ago is now quite a commonplace affair; and the methods and apparatus which characterize it are rapidly being outgrown by the large station of to-day. The great increase in total station output has, of course, advanced the output of individual units, and what with the necessity for greater output per unit and for restriction of site area in localities where land is precious, the newer type of steam engine has received an impetus that has resulted in the phenomenal development with which most of our readers are generally familiar. Only a few years ago regarded as an academic experiment, the steam turbine has apparently demonstrated its practicality to the extent of justifying orders for units rated in thousands of horse-power to perform work of the greatest importance and under conditions where failure would produce incalculable commercial diaster. The power house for the Pennsylvania Railroad Company's New York tunnel, for example, will contain steam turbines of 5000 horse-power output, one of which is now under construction; and the projected power house of the New York Central Railroad Company is to contain an equipment of steam turbines conservatively rated at 7500 horse-power each.

In central stations of modest output located remote from water-power sites, the reciprocating steam engine has hitherto been the sole dependence, and, parenthetically, it has lived up to its responsibilities far better than do most animate beings. Recent developments in the gas engine industry, however, indicate that a struggle for supremacy in this field is not far off. As noted in a recent issue of this paper, one of the largest steam engine builders of this country has arranged to build gas engines of large outputs which have been "tried out' in Europe; arrangements have just been made by still another engine builder to include large gas engines in its lines of production, and the excellent work already done along original lines by one of the oldest and best-known firms of the United States is familiar to all who are interested in the matter. This last-named concern has now in course of construction a gas engine of the four-cylinder duplex tandem double-acting type of 3000 horse-power rated output, and has already built numbers of two-cylinder tandem double-acting engines of smaller outputs.

The gas engine problem in this country, however, is not so much one of engine design as of power gas production. Where anthracite coal is plentiful, and therefore cheap, the matter is a simple one, but this is not the condition in the United States. The use of bituminous coal for producing power gas involves the "scrubbing" of the gas to remove the large quantity of tar distilled along with it, and this appears to be a considerable drawback. The tar must be extracted, of course; if allowed to go through the engine the valves and ports would become hopelessly clogged. Nevertheless, gas producing plants using bituminous coal are in operation in this country as well as abroad, and present indications are that the cleansing of the gas will eventually be accomplished with sufficiently small trouble and expense to make it an unobjectionable feature of the process. We are advised that a 200-h.p. producer plant using bituminous coal is in daily operation at Camden, N. J., and a large plant of the same character is to be started up next month in Indiana. Verily, the future of the gas engine and the steam turbine as prime movers for electrical stations appears to take on a roseate hue.

◆

The Single-Phase Motor.

From present indications it would seem that Mr. Ferranti's declaration made a few years ago to the effect that single-phase distribution would ultimately supersede the polyphase systems now considered practically indispensable was prophetic to a certain extent. That is, that the single-phase system may supersede polyphase distribution for some classes of service in which the single-phase motor has been generally regarded as hopeless. A single-phase railway system such as that of Mr. Lamme, for example, was generally considered absolutely impossible two years ago, and there still remain some who are skeptical concerning the actual commercial practicality of the series alternating-current motor in large outputs. The cold fact remains, however, that a full-grown car equipment of Mr. Lamme's system has demonstrated beyond argument that it is capable of actual performance equal in all respects to that of the direct-current series motor equipment, excepting, of course, its power factor. In a recent trial witnessed by the present writer, a double-motor equipment brought a car of usual size up to a speed of 45 miles an hour within 40 seconds and operated without any indications of distress at the brushes. The power factor of this type of motor is rather low at starting, but rises to around 90 per cent at ordinary speeds; the net watts taken from the line are almost proportional to the speed, and therefore to the load. In Europe also, the single-phase series motor has been successfully worked out for railway service, according to a paper read recently before the Italian Electrotechnical Association. The motor there described is a series wound commutator machine, similar to Mr. Lamme's, and speed regulation is effected in much the same manner, *viz.*, by the use of an auto-transformer with taps leading out for giving different voltages. According to the report of tests made with the Italian motor, its current-torque characteristic is practically a straight line within the working range; its power factor is above 90 per cent at all speeds above 750 r.p.m. (about 15 miles an hour with 33-inch car wheels and a gear ratio of 14:67); and its efficiency is from 70 per cent to 75 per cent within the usual working range.

Still further development has been made in this country with the single-phase motor, but we are unfortunately unable to say much about this on account of the status of the inventor's patents. We may say, however, that the machine is not a series-wound motor, that an actual test of it showed a power factor of 90 per cent to 98 per cent at speeds above 600 r.p.m., and that the torque developed is similar to that of a series motor with an unsaturated magnetic circuit, being proportional to the square of the current. This is one of the most interesting developments in single-phase motors that has yet come to our notice, and we hope to be able to give a full account of the machine at an early date. In view of the progress in single-phase motor design briefly noted herein, it appears to be safe to look for practical alternating-current traction at no very distant day, and the now "old-fashioned" single-phase alternator may again attain the pre-eminence which it enjoyed a few years back.

Transatlantic Wireless Telegraphy.

Just twenty months ago we printed an announcement, based upon press dispatches, to the effect that the Marconi Wireless Telegraph Company had made a definite contract with the Canadian Government for the establishment of a wireless system between Canada and England. According to the report, the Canadian plant equipment had then been ordered, and regular communication was to be established by June 1, 1902. At the same time we ventured to express the opinion that if such a contract had really been undertaken, it seemed to be rather rash procedure in view of the "state of the art." The flowery promises as to transatlantic wireless telegraphy continued to be issued from time to time for a considerable period after the first publication mentioned, but these promises appear to have something of the same flavor that characterizes Mr. Tesla's optimistic utterances.

Electric vs. Hydraulic Elevators.

At more or less frequent intervals we are asked why the relatively old hydraulically-operated elevator is superior to any electrically-operated elevator for high speeds. It usually requires considerable argument to convince the questioner that there is no fundamental superiority inherent in the hydraulic type of elevator hoisting mechanism, whatever operating superiority may have been actually found by observation having been due to the difference in the methods of applying the motive power. If we were asked why the average high-speed hydraulic elevator operates more satisfactorily in the long run than the average high-speed electric elevator, the answer would be easier.

The statement sometimes made that high-speed electric elevators have not yet been brought to a satisfactory stage is, however, untrue. We have knowledge of several high-speed types that equal the best hydraulic outfit ever installed so far as ease and accuracy of control, smoothness of starting, acceleration, retardation and stopping, and safety features are concerned. It is not the production of an electrically-operated elevator possessing these characteristics that makes the problem difficult, but the production of such a system which will not be too expensive to install, and which will also be sufficiently simple and rugged to get along with any sort of treatment or none at all. Electrical apparatus is admittedly more vulnerable than the ordinary machinery of hydraulic engineering and requires better care as a rule. This is especially true of the control apparatus characteristic of elevator mechanisms; in the one case one has a simple valve or set of valves which may be made as substantial as one chooses without entailing great expense, whereas, on the other hand, there is an inevitable array of magnets, relatively small contacts, comparatively delicate circuit-conductors, etc. Efforts to reduce the quantity and increase the durability of this auxiliary and particularly vulnerable apparatus usually result in impairing the smoothness and accuracy of control which is so essential in this class of work. The electric elevator problem is, therefore, to accomplish the results characteristic of complex, delicate and numerous parts by the use of a few rugged pieces of apparatus so arranged as to be fool-proof and needless of attention.

Technical Nomenclature.

It is greatly to be regretted that originators and users of slovenly technical expressions and abbreviations cannot appreciate the trouble they make for some persons and the pain they inflict upon others. If this appreciation could be forced home, there is little reason to doubt that the vernacular would speedily be cleared of such ridiculous expressions as "wattless current," "wattless power," "wattless watts," etc. Such careless habits as the use of the word "field" to indicate three or four different things, while deplorable enough, are at least explicable on the ground of simplicity of expression; it is so much more direct to say "field" simply instead of field-magnet, or field-magnet winding, or magnetic field, that one falls rather easily into the habit. There is no such excuse for "wattless current," "wattless watts," "trolley car," "rotary," "breaker," and several dozen more terms that we might mention.

As we have pointed out before, the term "wattless" might readily and logically be supplanted by "useless," so far as ordinary usage is concerned, despite the unpleasantly sibilant result when speaking. The lack of euphony is surely less objectionable than the silly contradiction resulting from the use of "wattless" as it is commonly applied. The contraction of "rotary converter" into a shorter term is natural enough, but since the name "converter" is not applied to anything except a rotary converter, why is not this preferable to the far less distinctive "rotary"? And the word "breaker" irresistably suggests coal mining and produces a feeling of extreme impatience whenever we hear it. In the first place, the name "circuit-breaker" was somewhat ill-advised because it made the adjective "automatic" necessary in order to differentiate between the electrically-operated overload switch and the plain manually-operated control switch. The name "limit switch," which has come into use in later years appears to be rather more descriptive than the older one, and has the merit of being easily pronounceable and not susceptible of mutilation. We might continue the discussion *ad nauseam*. The technical nomenclature of to-day, as both written and spoken, is sadly in need of revision.

CONSTRUCTION OF A MAGNETIC VANE VOLTMETER OR AMMETER.

BY J. C. BROCKSMITH.

The instrument shown in the accompanying working drawings is of the "magnetic vane" type, in which the current to be measured passes through a single coil of wire, at the center of which are located two thin iron vanes, one movable and the other stationary. The vanes become magnetized alike throughout their length by the action of the current circulated in the coil, and the resulting repulsion produces a deflection of the movable vane, against the force of a spiral spring, which is proportional to the strength of current flowing in the coil, and consequently can be calibrated to read directly in volts or amperes, according to the winding of the coil.

The instrument is obviously extremely simple both in principle and construction, and it has the additional advantage of being compact and of neat appearance, while being sufficiently accurate for all ordinary purposes.

Fig. 1 shows a front view of the instrument arranged as an ammeter. It will be noted from this view that the useful scale deflection extends over about 180° swing of the needle. The scale divisions, which are an almost exact reproduction of the 15-ampere scale in an actual instrument, are not of uniform length throughout, but have the peculiarity common to all instruments of this type in being open at the center and closing up at both extremities of the scale. The scale graduation is, of course, to be determined by comparison with a known standard instrument.

To produce the full scale deflection in the instrument as shown requires a magnetizing force of approximately 650 ampere-turns in the coil, and this can be derived from a small current circulating through a large number of turns as in the voltmeter winding, or it can be obtained from a large current flowing through a smaller number of turns as in the case of an ammeter winding.

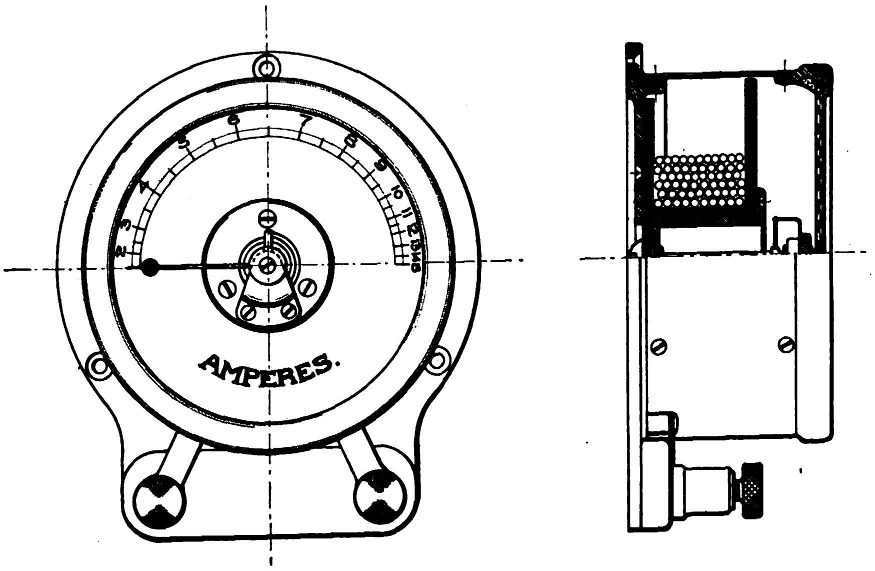

FIG. 1.—FRONT AND SEMI-SECTIONAL SIDE VIEW OF AMMETER.—FIG. 2.

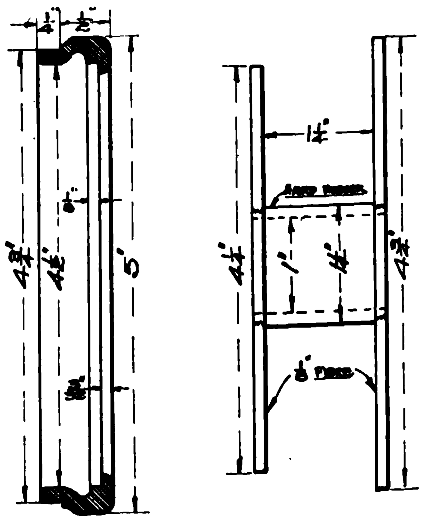

FIG. 4.—FRONT RING OF CASING AND SPOOL.—FIG. 5.

Fig. 2 is a semi-sectional view of the instrument which shows the general construction and relation of the parts. The coil is wound upon a fibre spool concentric with the circular casing of the instrument. The fixed and movable vanes are housed in a small flanged metal tube at the center of the spool, and the retarding spring and adjustment screw are located in front directly under the glass cover.

This view also shows how the circular glass cover is secured in its containing ring, this being accomplished by means of a small fillet of plaster of paris anchored in a groove which has been turned in the ring for this purpose.

The casing consists of two castings and a piece of sheet metal 2 inches wide, which is bent around and secured to the cast parts by means of small flat-head machine screws.

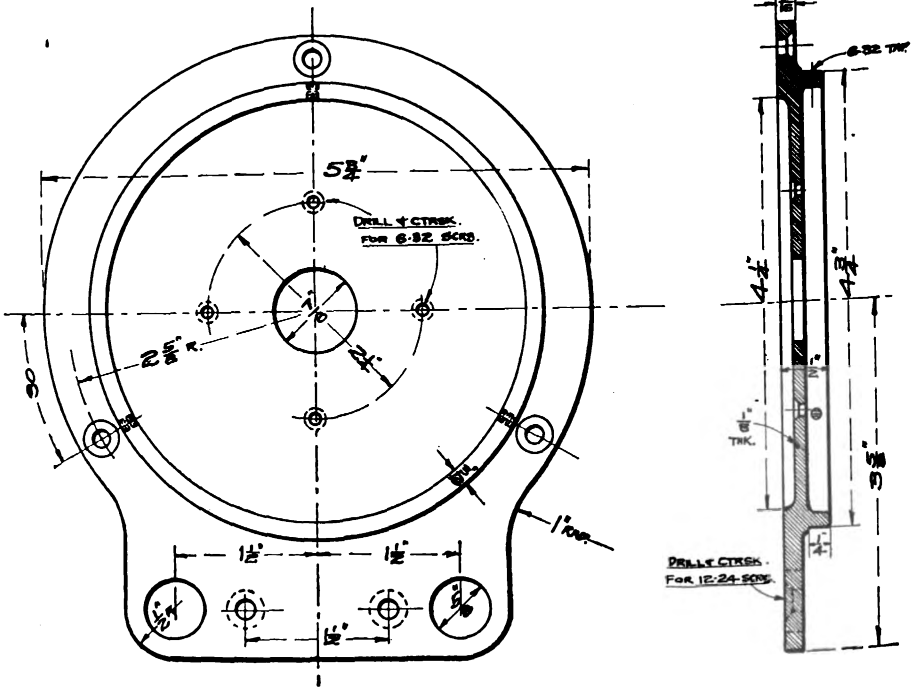

FIG. 3.—BACK PLATE OF CASING.

The binding posts are mounted upon a piece of ⅜-in. fibre, fastened to the back plate of the casing. When the instrument is to be used in a place where its magnetic conditions are likely to be disturbed by currents or the presence of iron, the case would best be made of iron to shield as far as possible the parts from outside influence. Ordinarily, however, it is practicable to use aluminum for the casing, which makes the instrument quite light in weight and also gives it a better appearance.

Fig. 3 is detail of the back plate. This is a casting of either iron or aluminum, as may be desired. There is very little machinery necessary on this part beyond the drilling and tapping of a few screw holes, but if of aluminum it should be finished bright on those surfaces which are exposed to view in the completed instrument.

Fig. 4 is a detail of the cover ring, in which the circular glass cover is mounted. This ring should be turned all over and polished. The glass should be cut out 4½ inches diameter and inserted in the ring and secured by means of a fillet of plaster of paris.

Fig. 5 gives the dimensions of the spool upon which the exciting coil is wound. This is built up of a pair of fibre heads threaded upon a short length of hard rubber tube. In the case of the voltmeter this spool will have to be wound almost completely full of fine wire in order to get the highest possible resistance and the least operating current. In the case of an ammeter the winding occupies less than half the spool, owing to the fact that the insulation on the wire occupies a smaller percentage of the total space available for winding. For a voltmeter reading to 120 volts maximum deflection the winding of the spool should consist of about 12,000 turns of No. 31 single-cotton-covered wire, and the current to produce the full scale deflection will be about .05 ampere. For a voltmeter to read up to 60 volts the winding should be composed of about 6000 turns of No. 28 wire. Almost any other winding can be obtained by varying the number of turns directly as the voltage and the cross-section of the wire inversely as the voltage.

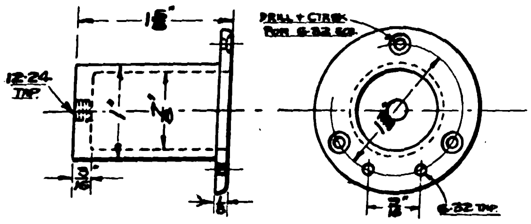

FIG. 6.—FLANGED TUBE.

For an ammeter to read to 15 amperes the spool would be wound with about 43 turns of No. 8 double-cotton-covered wire, or if this is inconveniently large to wind into so small a coil, two No. 11 wires may be used in multiple and wound side by side. Almost any range of scale for the ammeter can be obtained by allowing about 1000 circular mils per ampere in the wire for winding and making the number of turns such that with the full current flowing the magnetizing force will be 650 ampere-turns. For large currents it will be advisable to use copper ribbon, as this is easier to wind.

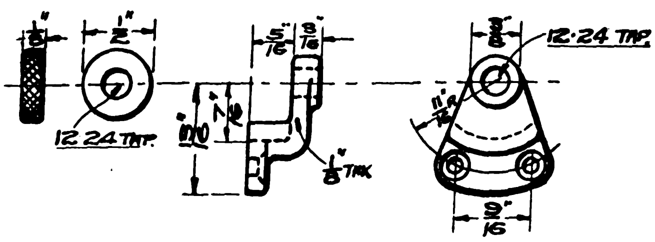

FIG. 7.—ADJUSTMENT SCREW BRACKET.

Fig. 6 is a detail of a small flanged tube, which is placed in the center of the exciting spool and which contains the fixed and moving vanes. This part may be made of aluminum and should be finished all over, the outside diameter being made to fit the spool. It is tapped centrally at one end for the jewel screw, and the flanged portion is also tapped for receiving the bracket (shown in Fig. 7), which contains the other jewel screw.

Fig. 8 shows the stationary vane, which is mounted in a thin copper tube closed at one end except for a small slit through which the moving vane is inserted. This tube is made a snug fit in the one shown in Fig. 6.

The stationary vane, which is soldered to the inside wall of this tube, consists of a portion which projects radially from the wall of the tube and extends from this in a circumferential direction for nearly 180°, tapering down almost to a point at its extremity. The object in this construction is to render the scale as nearly uniform as possible.

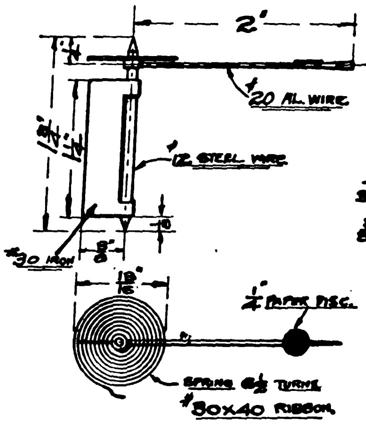

FIG. 9.—MOVING VANE AND SPRING.

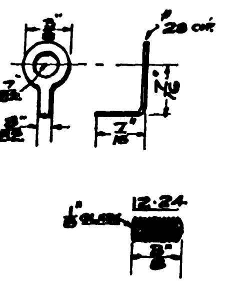

FIG. 10.—ADJUSTMENT SCREW AND SPRING CLIP.

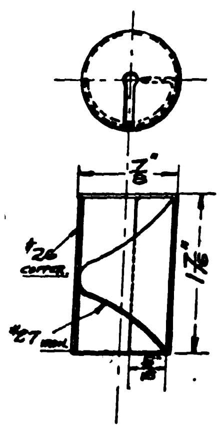

FIG. 8.—STATIONARY VANE.

Fig. 9 shows the moving system, which consists of a pivot pin of hardened steel (a short length of knitting needle will answer) ground down to a sharp point at each end, upon which is soldered a very thin soft iron vane. Both the fixed and moving vanes should be made of the very best quality of soft iron obtainable in order to eliminate as far as possible errors from residual magnetism and magnetic lag.

The retarding spring consists of 6½ turns of about No. 30 x 40 phosphor-bronze ribbon. A steel spring should not be used in this instrument as the convolutions have a tendency to stick together, thus rendering the readings inaccurate. The pointer consists of a short piece of No. 20 aluminum wire flattened at the end. It may have a small disc of thin blackened paper mounted on it by means of shellac, so that the position of the pointer can be observed at some distance.

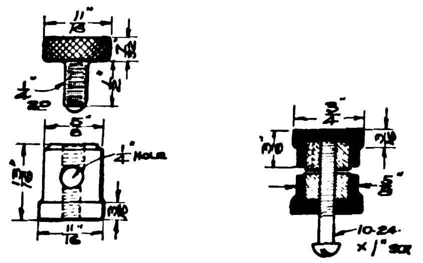

FIG. 11.—BINDING POSTS.

Fig. 10 shows the "jewel" screw and spring clip. The "jewel" may consist of a short piece of ⅛-in. glass rod, which has been heated in a Bunsen burner and formed with a small cup-shaped depression. It can then be cut off and inserted in a drilled hole in the end of the screw. It will not answer merely to form a depression in the metal of the screw itself as the needle is bound to stick in this case and produce inaccurate readings. If the builder can secure agate or ruby jewel screws so much the better.

The spring clip is a small piece of sheet copper which is bent down and soldered to the free end of the spring, while the other end is clamped under the thumb nut shown in Fig. 7.

Fig. 11 shows details of the binding posts for the ammeter and voltmeter. The ammeter post is simply of metal in the conventional form, while the voltmeter binding post is preferably of the insulated form, which can be most readily made by pressing a small metal button into a short length of hard rubber rod, which has been turned and bored to receive the button.

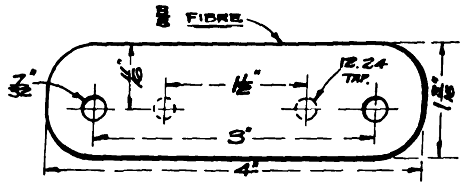

FIG. 12.—TERMINAL BLOCK.

Fig. 12 shows the terminal block; this can be made of hard wood or fibre ⅜ inch thick, and is fastened to the back plate of the instrument by means of a pair of flat-head screws passing into the block from the back.

The instrument which has been described, particularly when wound as an ammeter, can be used on alternating as well as direct current, but the same scale will not answer for both kinds of current. It requires to be calibrated for the particular kind of current on which it is to be used if any approach to accuracy is required.

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Long Distance Transmission Line. — The Washington Water Power Company, of Spokane, is about to begin the commercial operation of its 110-mile transmission line. The plant has already been operated at 60,000 volts, but with no load at end of the line.

CENTRAL ENERGY INTERCOMMUNICATING TELEPHONE SYSTEM.

BY H. S. WEBB.

In a previous article* several intercommunicating telephone systems using at least two wires for each station in order to eliminate cross-talk, were illustrated and briefly described. So much is heard nowadays concerning central-energy telephone exchange systems that it may be interesting to consider how the principles employed in some such systems have also been applied to intercommunicating systems.

Fig. 1 illustrates the principle used in some central-energy telephone exchange systems. The central battery, *B*, is connected through two coils, *I*, *I*, of high inductance to the line wires. At each end the primary winding, *p*, of an induction coil and a transmitter, *T*, are connected directly in series with the line wire. The impedance coils, *I I*, have a rather low ohmic resistance, but a very high impedance for the very rapidly fluctuating voice currents; hence, the steady current from the central battery, *B*, will readily pass through them, but the rapidly fluctuating voice currents are practically prevented from flowing from one line wire to the other through the coils and the central battery. The current from the battery, *B*, divides at the points *a*, *b*, part of it flowing through each line circuit. If the transmitter, *T*, increases in resistance, more current will flow through p', and conversely when *T* decreases in resistance, less current will flow through p'. The changes in resistance are produced so rapidly that there is practically no fluctuation of the current in *I*, *I*. The fluctuating current in p' induces an alternating current in the secondary winding, s', so that causes the receiver, R', to reproduce the words spoken into the transmitter, *T*.

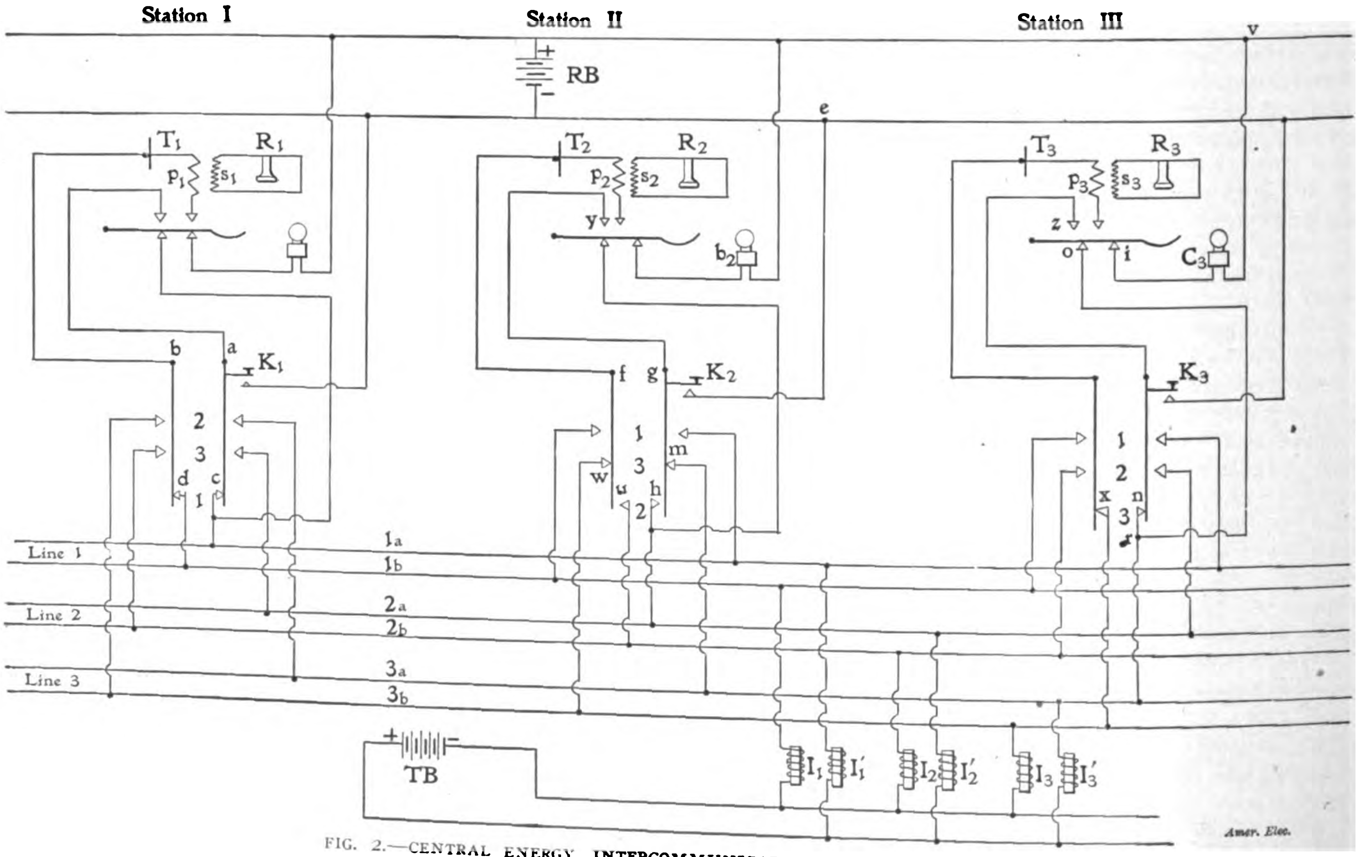

FIG. 2.—CENTRAL ENERGY INTERCOMMUNICATING TELEPHONE SYSTEM.

In the intercommunicating system shown in Fig. 2, this principle is employed. A common battery, *T B*, is used for talking purposes by all stations (only three are shown here, but more stations could be added in a similar manner), and there are two line wires for each station (used while conversing) in addition to two line wires used in common by all the stations for signalling purposes. The lines used for talking purposes are in pairs, designated line 1, line 2 and line 3. The battery, *T B*, is connected to each wire of each pair through the impedance coils, I_1, I'_1 I_2, I'_2 *and* I_3, I'_3 in exactly the same manner as shown in Fig. 1. In Fig. 2 each receiver and the secondary winding of the induction coil are similarly connected in a closed local circuit.

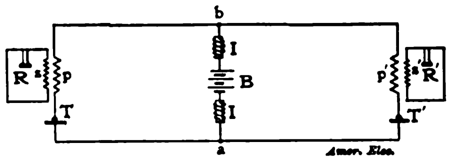

FIG. 1.—CENTRAL ENERGY TELEPHONE SYSTEM.

There is also a battery, *R B*, that is used by all stations for ringing purposes only. Both the batteries, *R B* and *T B*, may be located at some one convenient and centrally located point. The wiring of the telephone stations shown in this figure is suitable for use with an automatic or self-restoring intercommunicating switch. The normal position of the switch contacts is shown at Stations *I* and *III*; *a* and *b* represent springs so arranged that by pressing a push button located where the numbers 2 and 3 are placed the springs will be held in contact with the points on each side, and also separated from the home points *d* and *c* at the bottom. For instance, when push button 3 is pressed at Station *II*, the springs remain against contacts *w*, *m*, and separated from *u*, *h*, as there shown, until the receiver is taken down and replaced upon the hook.

The system operates as follows: To call Station *III* from Station *II*, press the button 3 at Station *II*, and then depress the push button, K_2. Current then flows from $+RB$ through *v*, C_3, *i*, *o*, *r*, line wire 3*a*, *m*, K_2, *e*, back to $-RB$. When K_3 is released and both receivers, R_2 and R_3 are removed from their hooks, current flows from $+TB$ through I'_3 to wire 3*a*, where it divides, one part flowing through *m*, *g*, *y*, lever p_2, T_2*f*, *w*, to wire 3*b*; and the other part through *n*, *z*, lever p_3, T_3, *x* to wire 3*b*, where the two parts reunite and return through I_3 back to $-TB$. The fluctuating currents flow, say, from T_2 through *f*, *w*, wire 3*b*, *x*, T_3, p_3, lever *z*, *n*, wire 3*a*, *m*, *g*, *y*, p_2, back to T_2; thereby inducing currents in s_2 and s_3 which properly affect the receivers R_2 and R_3. When the receiver, R_2, is hung on the hook, the springs *f*, *g*, are restored to their normal positions.

This is a good arrangement for use with an automatic switch when centralized talking and ringing batteries and two line wires for each telephone station are desired or considered necessary. By this arrangement all cross-talk and induction disturbances may be eliminated. The automatic switch made by the Couch & Seeley Company is suitable for this kind of system. The switch is very ingenious and positive in action, and the push button arrangement is convenient and fully as good, or even better than a rotating switch, which in this case would have to be double in some way.

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* Page 515, October, 1903, issue.

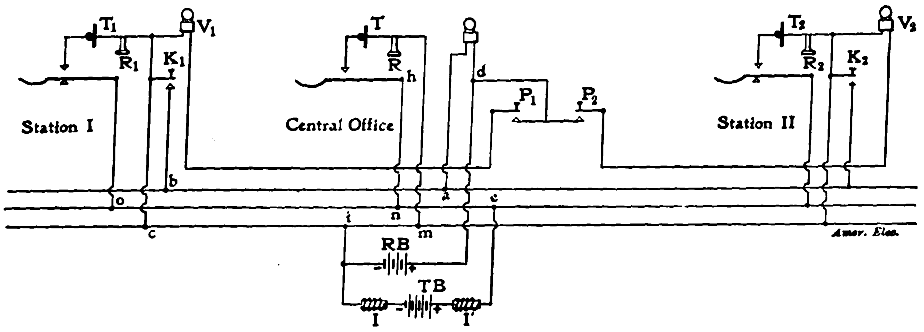

FIG. 3.—SPEAKING TUBE SYSTEM WITH COMMON BATTERY.

Fig. 3 shows a simple system that the Couch & Seeley Company designate their speaking tube system. It is suitable for a house, flat or building requiring only three or four telephones and where communication between a central office and the sub-stations only is required. No provision is made for calling one sub-station from another sub-station, but each sub-station can call up the central office and the central office can call up any sub-station. In short, it is a purely radial system. Only push buttons are required as switches, one push button at each sub-station and as many push buttons at the central office as there are sub-stations.

It is a central-energy system, the battery TB supplying all the current for the transmitters, and the battery RB all the currenting for ringing purposes. Impedance coils, I and I', are connected between the battery TB and the two line wires over which all the talking currents flow.

To call up the central office from Station *I*, for example, it is only necessary to press the push button, K_1, and current will flow from $+RB$ through the central office bell, a, b, K_1, c to $-RB$. When the receivers R_1 *and* R are removed from the hooks, battery current flows from $+TB$ through the impedance coil, I', junction e to junction n, where it subdivides, part flowing through h, T, R. m to i and part through n, o, T_1, R_1, c to i, where the currents re-unite and flow through the impedance coil I to $-TB$. The rapidly fluctuating voice currents flow from T_1 through R_1, c, m, R, T, h, n, o back to T_1.

When the central office wishes to call a sub-station, say, Station *I*, the push, P_1, is pressed and current flows from $+RB$ through d, P_1, V_1, c, i to $-RB$. The talking circuits are the same as before.

It will be seen that there are three wires running through all stations, and also one wire from the central office to each sub-station. If the central office and one sub-station were talking, the other sub-station could take down the receiver and hear all that was being said. However, the system is merely intended as a simple substitute for a speaking tube system, and is not supposed to meet the usual requirements of a regular telephone system.

INDICATOR DIAGRAMS.

BY CHAS. L. HUBBARD.

The indicator diagram is usually thought of in connection with the power of an engine, and is taken for this purpose more frequently than for any other. This, however, is not its only use, for by careful study it may be made to furnish much useful and interesting information in regard to the internal workings of the engine from which it is taken.

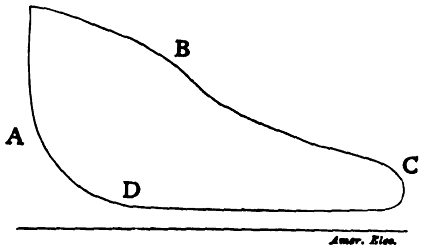

FIG. 1.

Sometimes when an engine appears to run so well that the owner is perfectly satisfied with its performance, a close inspection of its diagram may show a defective setting of the valve, a correction of which may result in a considerable saving. On looking at a diagram it sometimes appears at first sight to be faulty, while, as a matter of fact, for the given type, size and speed of engine, it may be the best that can be obtained. This is illustrated in Figs.

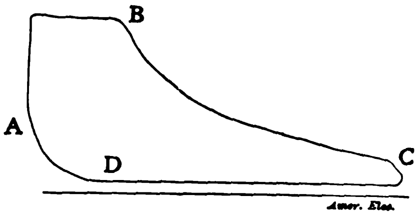

FIG. 2.

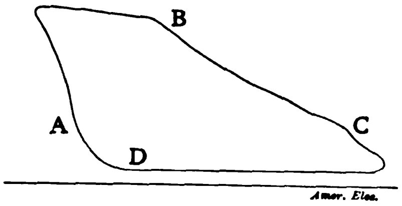

FIG. 3.

1 and 2, the first of which was taken from a simple non-condensing 8 in. by 10 in. engine, with a plain slide valve running at a speed of 200 r.p.m.; the second was from an engine with Corliss valve gear running at a speed of 80 r.p.m. Although there is little resemblance between the two, each was taken from a well-adjusted engine and represents the usual form of card for the two distinct types.

The most common faults in the distribution of steam in the cylinder may be divided into four classes, as follows: Too early or too late admission, too early or too late cut-off, too early or too late release, and too early or too late compression. In the following figures *A* is the point of admission, *B* the point of cut-off, *C* the point of release, and *D* the beginning of compression. In Fig. 3 the card shows too early admission. The admission line curves backward instead of being perpendicular to the atmospheric line as it should be. The diagram also shows that the other events—cut-off, release and compression—occur too early. If a plain slide valve is set so that one event is too early or too late, all the others are affected in the same way. The diagram of Fig. 3 shows too much angular advance and can be remedied by shifting the eccentric backward on the shaft. Fig. 4 shows a diagram having the opposite defects to those in Fig. 3. The events are too late; the admission line curves forward and shows that admission does not take place until after the stroke is well begun; release occurs at the end of the stroke. In this case the eccentric should be moved forward until the admission line is perpendicular to the atmospheric line.

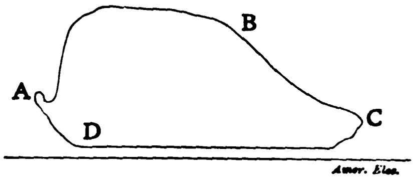

FIG. 4.

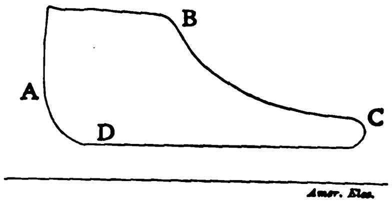

FIG. 5.

Fig. 5 shows a card having a considerable back pressure. This may be caused by small exhaust ports or pipe, or may be on account of the use of exhaust steam for heating, the mains and branches not being large enough. In other ways the form of the card shows a good distribution of steam. Fig. 6 shows a card in which the pressure is high at release. When an engine runs under these conditions much of

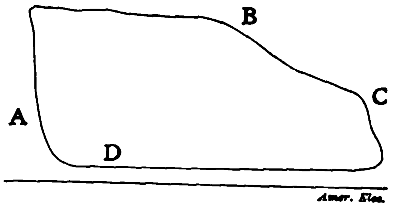

FIG. 6.

the steam is wasted as the advantage due to expansion is not obtained. Fig. 7 is from a condensing engine, and therefore the back pressure line comes below the atmospheric line. The wavy admission line is due to the vibrations of the indicator parts at high speed. In measuring the area of a card of this kind an average line may be drawn, as shown by the dotted line in the figure, and this may be taken as the true outline of the diagram. Fig. 8 shows a pair of diagrams taken from a slide valve engine. The admission lines are good, but the sloping steam lines show wire drawing which may be caused by the slow action of the valve, or be due to too small ports or steam pipes. Wire drawing decreases the area of the card and indicates a loss. Another fault is the inequality of areas of the cards for the two ends of the cylinder, which is due to late cut-off and compression at one end and to early cut-off and compression at the other. These cards can be improved by adjusting the angular advance of the eccentric and the length of the valve rod.

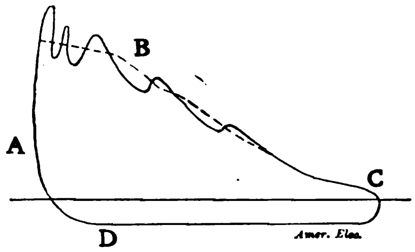

FIG. 7.

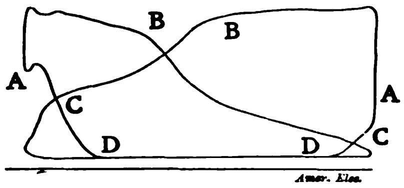

FIG. 8.

The diagram in Fig. 9 indicates too early compression, the compression curve extending above the initial pressure line. The area of the loop must be subtracted from the area of the card when computing the indicated horse-power. If the cut-off is kept the same and the compression made what it should be, the gain in area would be that included between the full and dotted lines plus the area of the loop. The remedy for this is to increase the inside lap.

The proper amount of compression depends upon the speed and type of engine. Slow-speed engines require less compression than those with high speeds. The steam remaining in the cylinder during compression should never be compressed beyond the initial pressure. For engines running at high speeds the amount of compression should be about 0.9 of the initial pressure; for medium speeds, about 0.5, and for low speeds, from 0.2 to 0.4. In the case of a slide valve engine it is not always possible to set the valve so that the card will have all the events as they should be, and sometimes it is necessary to change the laps. For too much compression decrease the inside lap; for too early cut-off decrease the outside lap. If the valve travel is increased, compression is decreased and release is retarded.

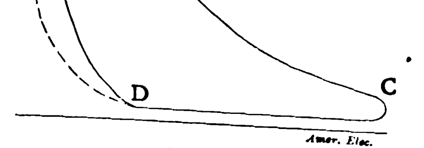

FIG. 9.

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A MAGNETO SWITCHBOARD FOR SMALL EXCHANGES.

BY A. DALLAM O'BRIEN.

Telephone switchboards of the magneto type, in which the talking current for the sub-station instruments is furnished by local batteries located at each sub-station, have been almost entirely superseded in all the large and medium-sized exchanges in the country by the central energy or common battery type of switchboard. In a great number of small exchanges, however, where the expert attendance and supervision necessary for a common battery board is not available, the simplicity and freedom from complicated circuits of the magneto board renders it especially suitable, and consequently this type of board is in use in the small country exchanges to a very great extent at the present time. It is the purpose of this article to describe the wiring, circuits, equipment and method of operation of a magneto switchboard having a capacity of 100 sub-station lines, and as it is the usual practice in country exchanges to connect a number of instruments to a single line, the number of sub-stations that may be served from a board of this capacity may, and often does, approach 400 or 500.

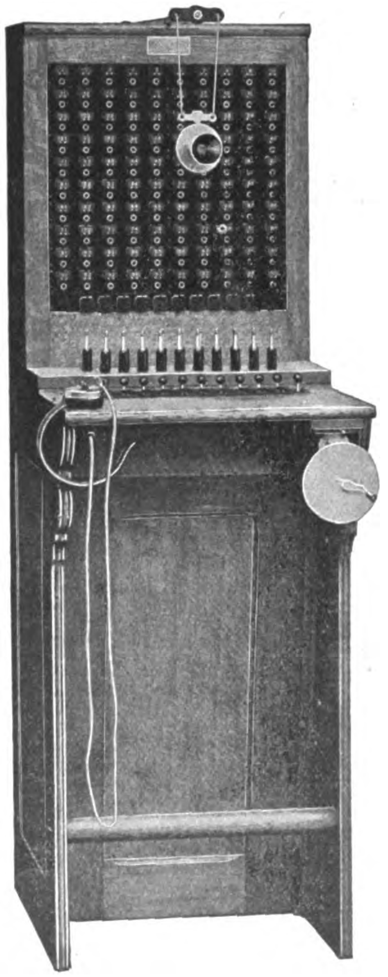


FIG. 1.—MAGNETO SWITCHBOARD.

As it is necessary where a number of stations are connected on one line, and where a system of selective ringing is not used, to have distinctive signals for each station so connected, a point will soon be reached where the number of distinctive signals will become burdensome to the operator; at the same time, the number of originating calls per line will increase with each additional station and the volume of business will become too great for one operator to handle. It is good practice, therefore, with a 100-line switchboard, to limit the number of stations per line to four, as with this number the distinctive signalling will not prove difficult, and except in extreme cases the traffic through the board can be readily handled by a single operator.

In Fig. 1 is shown a front view of the switchboard, which is about 6 feet high, 23 inches wide, and 20 inches from the front of the keyboard to the back of the casing. The board is built of mahogany or oak, as may be desired, and is equipped with 100 combination jacks and self-restoring drops, 10 pairs of connecting cords and 10 combination ringing and listening keys, in addition to the operator's telephone set, transmitter arm and induction coil and a hand magneto generator for signalling purposes. The clearing-out drops, one of which is included in each cord circuit, are the usual type of tubular drop and are wound to any desired resistance, usually not higher than 650 ohms. The combination drops and jacks are mounted in the face of the board on 1¼-in. horizontal and 1½-in. vertical centers, thus allowing ample clearance for the plugs when two adjacent jacks are in use. The clearing-out signals are mounted in a single row of ten below the line drops and jacks, as shown in Fig. 1.

The switchboard is not provided with a connecting rack, and the lines coming into the exchange are first led to protectors and sneak-current arresters, which are mounted in a wall cabinet in the operating room, if possible; the circuits then pass by means of 20-pair switchboard cables to the board. These cables are run up the inside of the board, stripped, waxed, formed up and connected to the jacks. The wiring from the ringing and listening keys in the keyboard to the cord shelf and clearing-out drops is formed up into a cable of No. 22 silk and cotton-covered switchboard wire and connected in the usual way.

Fig. 2 shows the construction of the combination drop and jack, the three springs of the jack and the connection of one side of the line to the drop magnet being clearly shown. The drop is mechanically restored to its normal position (with the shutter up) by the action of the operator inserting a plug in the jack. In Fig. 3 is shown the construction of the combination listening and ringing key, the former being actuated by a push-button and the latter by a cam, as shown.

Fig. 4 shows the wiring diagram of a subscriber's party line, three instruments being shown connected to the same line. Each instrument is provided with a local battery consisting of two cells of any good type of wet or dry battery and an induction coil, the primary circuit of which is closed through the battery and transmitter when the receiver is removed from the hook. In addition each sub-station instrument is furnished with a hand magneto generator for signalling the central office and a polarized bell for receiving signals. The generator is normally disconnected from the line and is automatically connected thereto when the subscriber turns the crank in order to signal. The bells at the subscribers' stations in Fig. 4 are shown permanently connected across the line, and in consequence, when any station signals the central office all the bells connected to the line will receive a portion of the current generated and will ring, thus notifying every subscriber, as well as the central office operator, that a call is being made.

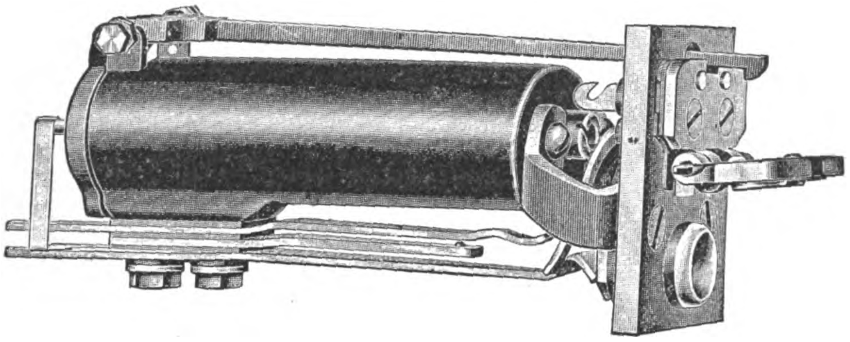


FIG. 2.—COMBINATION DROP AND JACK.

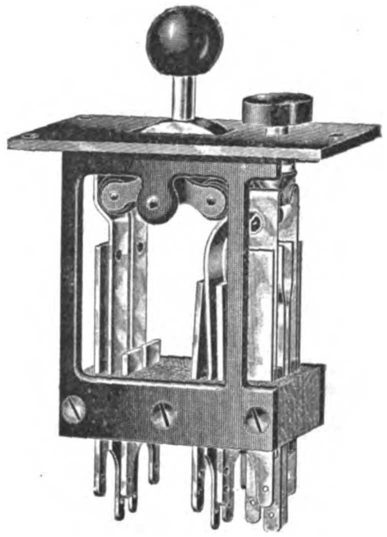


FIG. 3.—COMBINATION LISTENING AND RINGING KEY.

It is possible, however, to arrange the connection of the bells in a number of ways, so that this feature may be avoided. The switchboard drop may be made of low resistance, so that practically all the current generated will pass through the drop and the bells will not receive sufficient current to operate them; this arrangement is only practicable, however, where the drop is cut out of circuit by the insertion of a plug in the jack. Another and more satisfactory arrangement is to provide generators at the subscribers' stations which generate in one direction only, and to arrange all the bells connected to the line, so that their armatures are normally attracted toward the pole which is strengthened by the uni-directional current. The generator at the central office, however, is arranged to furnish alternating current.

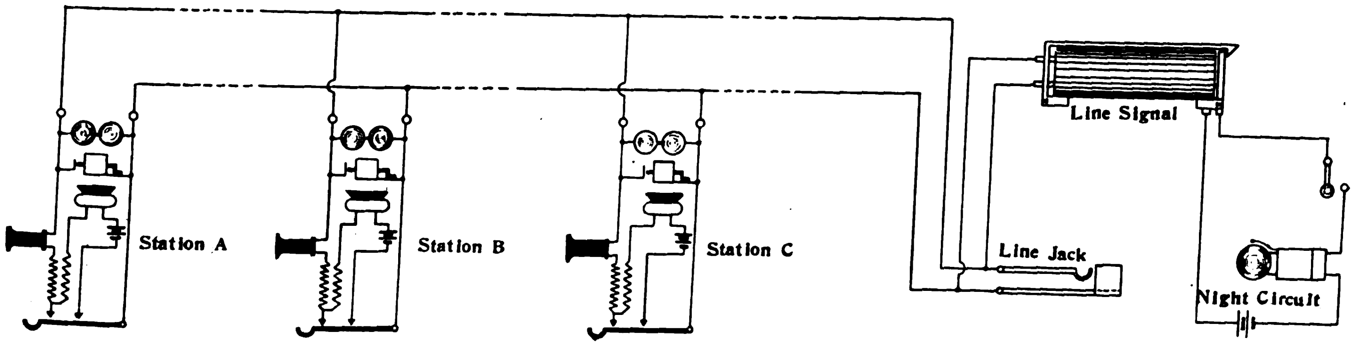


FIG. 4.—WIRING DIAGRAM OF A SUBSCRIBER'S PARTY LINE.

Fig. 5 shows the wiring diagram for the connecting cord circuit at the switchboard. The cords and plugs are of the two-conductor type, the ring and sleeve of one plug being connected to the ring and sleeve respectively of the other plug through the ringing key. The combination ringing and listening key is connected in multiple across the cord conductors, and the ring-off or clearing-out drop is normally bridged across the line through the inner contacts of the combination key, as shown. The operator's set is connected to the listening side of the key, so that when the cam is operated in one direction the secondary winding of the induction coil and the operator's receiver are bridged across the cord circuit and the operator's set connected to the sub-station through the cord. The operation of the cam in the reverse direction enables the operator to ring out over the answering plug, while the operation of the ringing key button allows signals to be sent out over the calling plug. The primary circuit of the operator's set consists of the usual series arrangement of battery, transmitter and primary winding of the induction coil. As shown in the diagram, the primary circuit is kept constantly closed, but in practice it is usual to connect the primary circuit through contacts in the operator's jack, so that this circuit is only closed during the time that the operator's plug is inserted in the jack.

In cases where the traffic to be handled is small, the hand generator for signalling purposes will probably suffice; but it needs no explanation to prove that where this is the only available means for signalling, the number of calls which an operator can handle in twenty-four hours will be comparatively small, as the necessity for turning the crank at frequent intervals consumes considerable time. For this reason it is usual to employ a hand generator only as an auxiliary means to be used in case of an accident to a continuous external supply of ringing current. There are a number of means by which ringing current may be furnished to the switchboard. A water motor belted to a small alternating-current generator is often used where the water supply is available. A motor-generator operated from some outside source of current is frequently employed, but in the majority of small exchanges the ringing current is furnished by a pole changer.

The pole changer consists of a vibrator, which is connected in circuit with a closed-circuit battery and operates continuously. The vibrator operates in very much the same way as does the clapper of the ordinary vibrating bell, and it carries a number of contacts which serve to make and break the circuit and reverse the direction of the current flow from a number of cells of battery connected in series. Pole changers are constructed so as to furnish alternating current and also pulsating unidirectional currents, and can, in consequence, be used for selective signalling. The voltage furnished can be made as high as desirable by providing the requisite number of batteries in series, and as current is only drawn from the batteries during the time that the switchboard operator is signalling a subscriber, the operation of the pole changer is highly economical.

The operation of a switchboard of this type, while it involves more labor on the part of the subscriber than does the common battery board, is exceedingly simple. To call the central office, the subscriber operates his hand generator and throws the drop at the exchange; the operator answers with the back cord of a pair, throwing her listening key to learn the connection desired. The required station is signalled by the operator, who rings on the front cord and supervises the connection until the called party has answered. Upon the termination of the conversation, the connected parties hang up their receivers and give a few turns to the crank of the hand generator; this serves to operate the clearing-out signal, which is bridged across the cord, as previously explained, and notifies the operator, who disconnects. Where a subscriber on a party line wishes connection with another subscriber on the same line, and informs the operator to that effect, he hangs up his receiver and waits until he hears the signal of the party desired. This signal will, of course, on a bridged line, be transmitted to every bell on the line. The connection is then handled in the usual way.

It is obvious that unless means were taken to prevent it, subscribers on the same line could arrange a code of signals so that they might be able to hold conversations between themselves without the knowledge of the operator, and this condition on lines where the charge is based upon a message rate might result in considerable loss; hence the necessity for making provision that when a subscriber signals the central office, the other subscribers' bells will not ring.

It is oftentimes desirable to run trunk lines between small exchanges of this type which are located within a few miles of each other. The circuits of such trunk lines involve no especially interesting features; the trunk line usually terminates in a jack at each exchange and has at either end a drop bridged across the line, this drop preferably being arranged so that it is cut out of circuit by the insertion of a plug in the jack. Where magneto exchanges are located in the outlying districts of large cities and are connected by trunk lines to the common battery central office in the city, the connecting lines may be wired in a great variety of ways, which will depend largely upon local conditions, and to a great extent upon the difference of ground potential between the two points, in cases where automatic signals are used on the trunks. In order that the effect of the subscribers' bells, which are bridged across the lines, may not serve to hamper the transmission, the ringer coils are usually wound to a resistance of about 1000 ohms with No. 33 magnet wire, although in some cases the coils are wound to a resistance of 1600 ohms with No. 38 magnet wire. The object is to produce a high impedance in the bell coils to the rapidly fluctuating talking current, and in order to produce this impedance it is necessary to wind the coils with a great number of turns.

The board and auxiliary apparatus described are built by the Farr Telephone & Construction Supply Co., of Chicago, Ill.

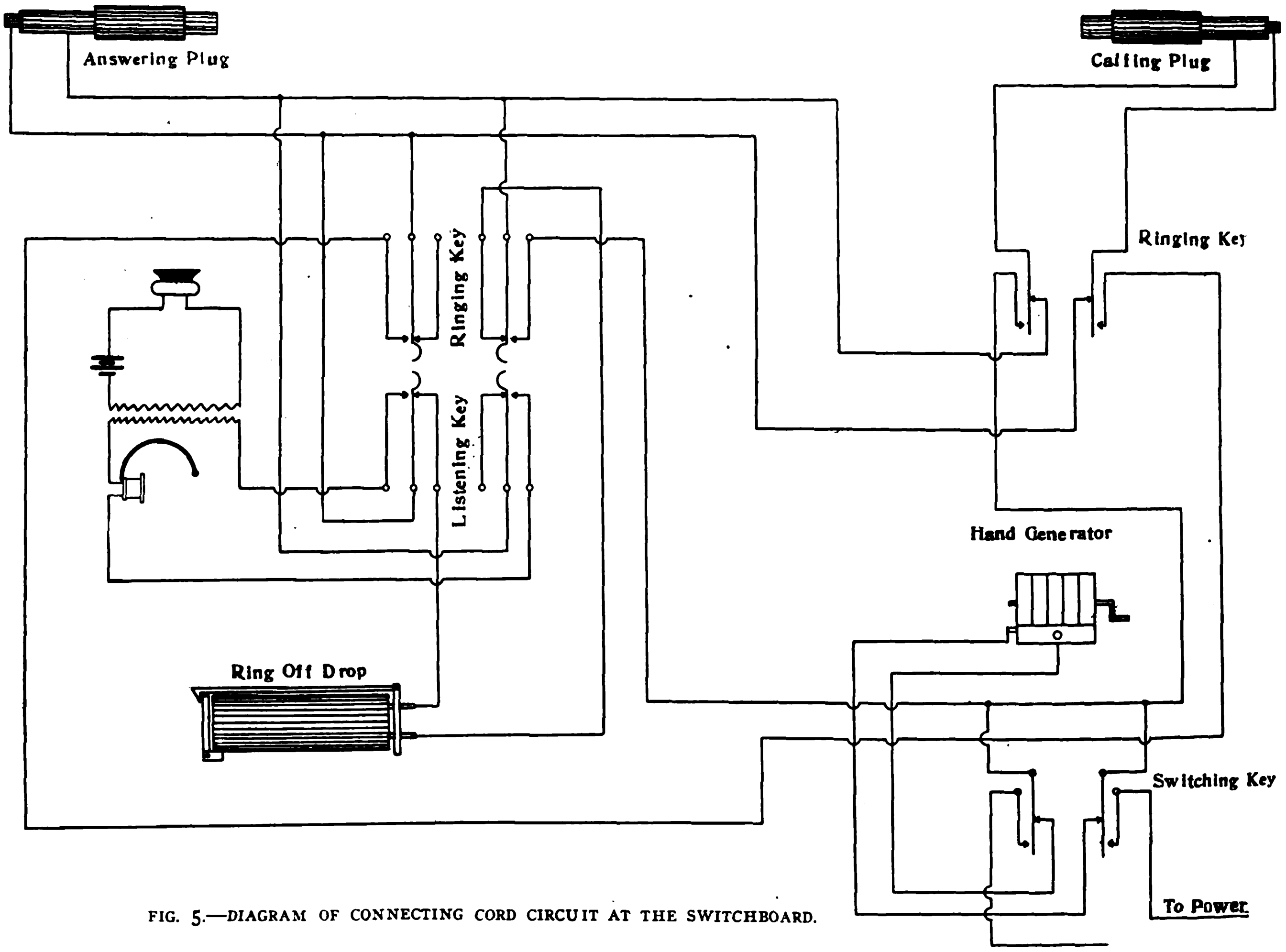


FIG. 5.—DIAGRAM OF CONNECTING CORD CIRCUIT AT THE SWITCHBOARD.

THE THREE VOLTMETER METHOD OF MEASURING ALTERNATING-CURRENT POWER.

Mr. John D. Nies gave a lecture before the Chicago Electrical Association, November 20, on the split-phase method for the measurement of power in alternating-current circuits, this lecture being the modification of one of the regular lectures which Mr. Nies gives in his instruction course at Lewis Institute. Although the three-voltmeter method of measuring power is not new, a review of Mr. Nies' presentation of the subject may be of value to those not familiar with this method or to those familiar with the formula, but not acquainted with the method by which it is derived. Mr. Nies said, by way of introduction, that the three-voltmeter method of measuring power in alternating-current circuits was sometimes valuable where wattmeters were not at hand and the limits of error by this method were not likely to be any greater than with a wattmeter. It is sometimes erroneously assumed that the shunt coil on the wattmeter has no self-induction, and this frequently leads to errors in results.

In making a test by the three-voltmeter method, a non-inductive resistance, such as a bank of lamps, is connected in series with the inductive apparatus in which the power is to be measured, as in Fig. 1, where M represents a motor the input of which is to be measured; A is an ammeter in the supply circuit measuring the current delivered, and in series with it is a bank of lamps *L*. Three voltage readings are then taken as indicated by voltmeters V_1, V_2 and V_3, and these three readings are plotted in a triangle, as in Fig. 2. The reading of V_1 is represented in value by the line *O-A;* the reading of V_2 is represented by the line *A-B*, and the reading of V_3 by the line *O-B*. The voltage *O-A* across the non-inductive resistance is, of course, in phase with the current; the voltage *A-B* across the motor terminals is out of phase with the current on account of the inductance of the motor. Since the current and voltage in the non-inductive resistance are in phase, the line representing the current may be drawn out along the line *O-A* to any convenient scale, giving *O-C* in the figure. It is evident that the lag of the current with respect to the impressed voltage for the entire circuit is the angle *B-O-C*. In the motor circuit the lag of the current behind the e.m.f. is the angle *B-A-C*, which would be 90 degs. if the motor windings consisted solely of reactance, but since these also have some resistance, the effect of the resistance will be to draw the e.m.f. and the current nearer into phase, making *B-A-C* less than 90 degs. Triangle *B-A-C* gives complete information concerning phase relations in the circuit. The sole purpose for which the resistance is employed is to give a voltage reading which will serve to locate the position of the current wave with respect to the e.m.f. wave. Having found the angle of lag (and hence the power factor) for the motor circuit, one might determine the power by separating the current into its two components, one in phase and the other 90 degs. behind the e.m.f., and multiplying the e.m.f. by the component of the current which is in phase. The calculations might be made graphically by sufficiently accurate drawing instruments, but this is not recommended, because of the chances of error and the necessity of having drawing instruments at hand. It is recommended instead that in taking the measurements, a free-hand sketch of the triangle be made, with the values of each component as read from the instruments noted on each line, and that the value of the power factor be afterward calculated. The formula is as follows:

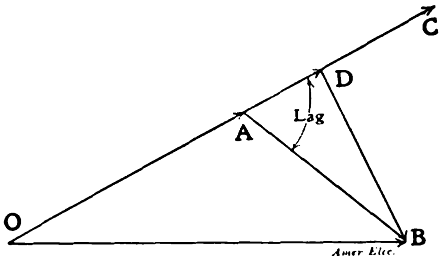


FIG. 2.

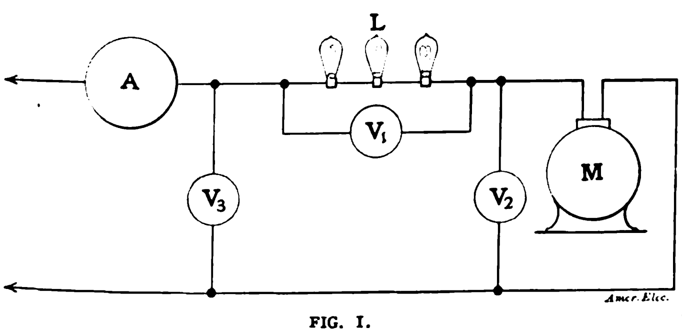


FIG. I.

$$\frac{V_3^2 - V_2^2 - V_1^2}{2 V_1 V_2} = \text{Power factor.}$$

In this formula the symbols represent respectively the readings of the voltmeters which are indicated in Fig. 1 by the same symbols.

[Having the power factor, the true watts delivered to the motor may, of course, be obtained by multiplying the product of the voltage and current by the power factor. Representing the current by *A*, the voltage by V_2 as before, and the power factor by *p*, the formula for true watts is:

$$A \times V_2 \times p = \text{Watts},$$

and substituting in this the equivalent of the power factor value according to the previous formula, one may compute the true watts directly from the readings of the instruments without first computing the power factor, thus:

$$\frac{A}{2} \times \left(\frac{V_3^2 - V_2^2}{V_1} - V_1 \right) = \text{Watts.}$$

This method is especially useful in measuring the power taken by alternating-current series arc lamps.—EDITOR.]

◆

THE HOT WATER METER FOR BOILER EVAPORATIVE TESTS.

BY JOHN A. DREW.

Every engineer who has control of a boiler plant must feel the necessity of having some simple device by which the amount of water fed to the boiler can be accurately measured. With such an application at hand, it becomes an easy matter to test the evaporative values of various coals with a view to determining which of the several is the most economical in developing power. There was a time when it was not considered necessary to keep a close record of the cost of operation of large power plants, but there are few, if any, plants to-day that do not keep close records, which always include the coal consumption. But while this is valuable information in itself, it is only part of the data that should be obtained. If the amount of water evaporated is not known, there is no way of separating the performance of the boiler itself from the balance of the plant. This separation is important, indicating as it does, the efficiency of the boilers. It shows when the boiler is affected by scale or soot and determines the most economical fuel, as well as determining the best method of firing, either by hand or by mechanical stokers.

In the past, the customary method of determining the amount of boiler feed water has been by weighing or measuring it. This is a very laborious method, even for short tests, and is utterly impracticable for daily work. The use of the feed water meter, on account of its simplicity, accuracy and reliability in evaporative tests, is now most universally adopted by engineers for daily work, as well as for trial tests.

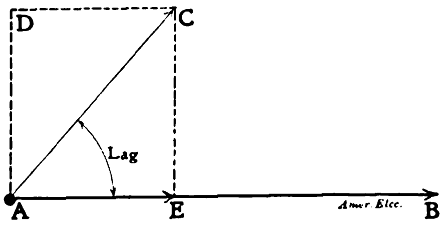


FIG. 3.

The most reliable test meters are of the positive displacement type, a well-known form of which is the Worthington duplex meter, which measures water by the means of two chambers alternately filled and emptied by the motion of their pistons. These meters are so constructed that it is impossible to pass water without a corresponding registration, for in order to pass through the meter the water must be displaced by the motion of the pistons, and, therefore, recorded by the counter attachment. One of these is shown by Fig. 1. The pistons are closely fitted and move in parallel lines. The design, arrangement and construction of valves and parts is such that the strokes of the two pistons alternate, the valves actuated by one admitting pressure to the other. At the end of each motion, the pistons are brought to rest by adjustable buffers, which determine the length of the stroke. One of the pistons is constantly in motion, so that there is a uniform flow of water, free from pulsation or shock.

These test meters are constructed of materials uniformly affected as to expansion and contraction by differing temperatures in order to avoid inaccuracy due to unequal expansions. For an ordinary test, one of these meters was calibrated, and by deducting the weight of water as found by the meter registration from the actual tank weight, the figures showed the meter to be

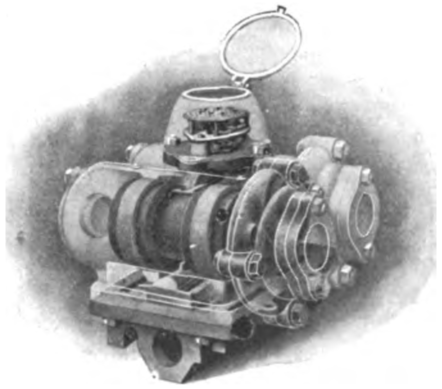


FIG. I.—DUPLEX WATER METER.

correct to within one-fifth of one per cent. This is considered a very satisfactory showing for ordinary every-day work. To obtain correct results, these test meters should be properly applied for operation, the size selected should be ample for the service, insuring slow piston speed, and the pipe connections should be made so that at any time the meter can be cut out for examination or repairs without shutting down the boilers.

Lessons in Practical Electricity

INDUCTION. INDUCTANCE. THE INDUCTION COIL.

As has already been explained in a previous Lesson, a conductor in which a current is flowing is surrounded by magnetic lines of force, which are close together near the conductor, but further and further apart as the distance from it increases.

This condition of things may be represented diagrammatically by Fig. 1, in which case the lines of force are concentric circles. Evidently, since the presence of the lines of force is due to the fact that a current is flowing in the conductor, the greater the current strength, the greater will be the number of lines surrounding the conductor.

If the current is supposed to flow into the conductor in a downward direction perpendicular to the plane of the paper, the lines of force will all be parallel to the plane of the paper, and their "direction" clockwise. If a number of small compasses were arranged around the conductor, as shown in Fig. 2, so that their needles would point as indicated when no current is flowing in the conductor, when a current is sent downward through it, the needles would immediately set themselves as shown in Fig. 3, so that all the north poles would appear to have a tendency to go around the conductor in a right-hand or clockwise direction; and they would remain in this position as long as the current continued to flow.

It will be remembered that whenever a conductor is moved so as to cut magnetic lines of force, an e.m.f. is set up in it, the same is true if the lines of force are made to cut the conductor. Now, returning to Fig. 1, if the current in the conductor is suddenly interrupted, all the lines of force about the conductor will collapse upon it and the energy which was originally necessary to produce them will be expended in setting up an e.m.f. in the conductor. This phenomenon is called "self-induction," and the e.m.f. thus set up the "e.m.f. of self-induction."

When a circuit is closed, the same phenomenon takes place, because the conductor carrying the current is suddenly surrounded by lines of force, which may be considered as starting at the centre of the conductor and expanding outwardly as the current increases; so that each line of force cuts the conductor as it is set up.

The e.m.f. induced upon closing the circuit will be such as to oppose the current in the conductor, while that induced upon opening the circuit will tend to help the current to continue flowing, so that the effect in either case is to oppose a change of conditions.

If instead of being straight, the conductor is wound in spiral form, as shown in Fig. 4, adjacent turns being well insulated from each other, the lines of force will cut the conductor many times instead of once when the circuit is closed or opened, and consequently the e.m.f. of self-induction will be correspondingly greater.

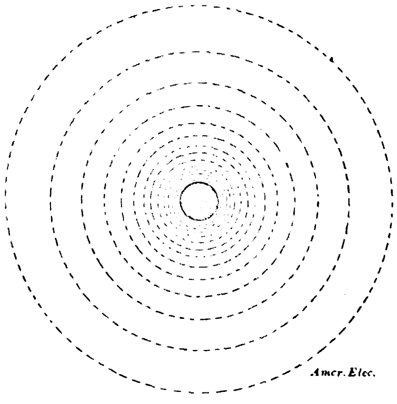


FIG. 1.

If the conductor is wound upon a soft-iron core (adjacent turns being well insulated from each other and from the core), the number of lines of force about the conductor will be much greater than it would be without the core, because of the great increase in the magnetic conductivity, or permeability of the path through which the lines pass, as already explained in a previous Lesson; consequently, upon the establishment or interruption of a current in the conductor, the e.m.f. of self-induction will be much greater than it would have been without the core.

If a coil has N turns of conductor and the total number of lines of force threading through it is Φ, this number of lines will cut the conductor N times when the circuit is closed or opened; the result will be the same as though the conductor had been cut by $N \times \Phi$ lines of force. Let L represent the total amount of cutting of lines by the conductor when one ampere is suddenly started or stopped in it; then for a current, I, in amperes, $L\ I = N\ \Phi$, from which

$$L = \frac{N\Phi}{I}$$

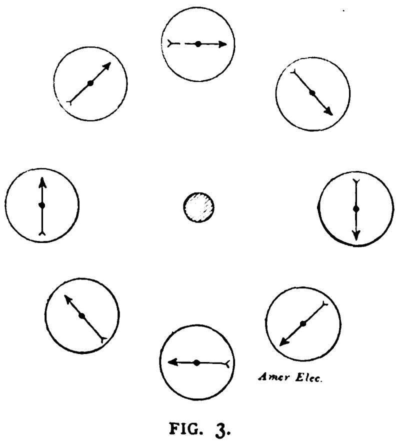


FIG. 3.

As has been explained in a previous Lesson, for a coil without an iron core (in which case the permeability of the magnetic circuit is unity),

$$\Phi = .4\,\pi\,I\,N$$

so that

$$L = .4\,\pi\,N^2.$$

This quantity, L, is called the "inductance," or "coefficient of self-induction" of the circuit. The unit of inductance is called the "henry," and corresponds to a cutting of 10^8 lines of force when a current of 1 ampere is started or stopped in a circuit; so that the formula for inductance in henries is

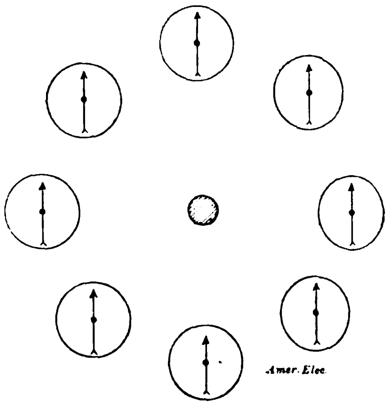


FIG. 2.

$$L = \frac{.4\,\pi\,N^2}{10^8.} = 4\,\pi\,N^2\,10^{-9}.$$

If the circuit is wound upon an iron core and the magnetic circuit is closed, the formula for inductance in henries will be

$$L = \frac{4\,\pi\,N^2}{R \times 10^9}$$

where R represents the reluctance of the magnetic circuit in oersteds. As the permeability of iron is variable, and consequently the reluctance inversely so, only an approximate calculation can be made of the inductance of a circuit wound upon an iron core.

A familiar example of the effect of self-induction is the "kick" which occurs when the shunt-field circuit of a dynamo or motor is suddenly opened; and the e.m.f. producing it is many times greater than that of the line. In fact, it is frequently great enough to puncture the insulation of the field winding.

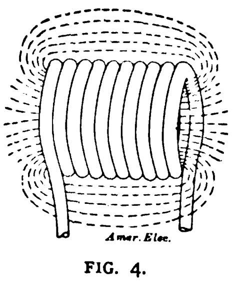


FIG. 4.

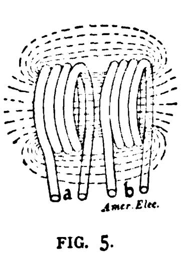


FIG. 5.

Suppose that two coils of wire, *a* and *b*, both being well insulated, are placed side by side, as shown in Fig. 5, and a current is started in one of the coils, *a*; the lines of force set up around the conductors of that coil will cut the conductors of the other coil, *b*, and consequently will induce an e.m.f. of momentary duration in it. When the magnetic flux attains full value, the induced e.m.f. ceases, because the lines of force are stationary, so that there is no "cutting." Now, if the current is suddenly stopped in *a*, the lines of force in collapsing will cut the conductors of coil, *b*, setting up an e.m.f. in the opposite direction from that set up upon closing the circuit, as the relative motion between the conductors and lines of force is opposite in the two cases. This phenomenon is called "induction" and the e.m.f. set up is the "e.m.f. of induction." If *all* the lines set up by one coil, *a*, cut *all* the wires of the other, *b*, the e.m.f. induced in *b* will be approximately the e.m.f. of coil *a* multiplied by the number of turns of wire in coil *b* and divided by the number of turns of wire in coil *a*.

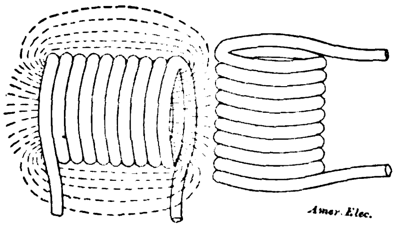


FIG. 6.

.If each of the coils is wound upon a soft-iron core, or both upon the same core, the effect will be greatly increased for the reasons already explained in a previous paragraph regarding the case of the self-induction of a single coil.

If the coils are placed so that their planes are at right angles to each other, as shown in Fig. 6, no inductive effect will be produced in one coil by establishing or interrupting current in the other, because none of the lines of force around the conductors of the coil carrying current will cut the conductors of the other coil. In any other position of the coils, induction will take place, the extent depending upon the angle between the planes of the coils and the other conditions already explained.

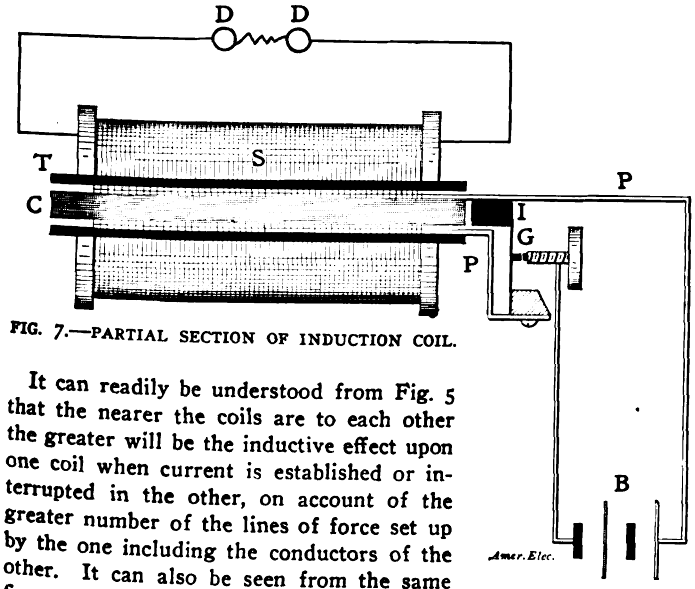


FIG. 7.—PARTIAL SECTION OF INDUCTION COIL.

It can readily be understood from Fig. 5 that the nearer the coils are to each other the greater will be the inductive effect upon one coil when current is established or interrupted in the other, on account of the greater number of the lines of force set up by the one including the conductors of the other. It can also be seen from the same figure that as the number of turns of conductor in the coil *b* is increased, more of them will be cut when the circuit is broken in the coil *a*, and consequently the e.m.f. in *b* will also be increased. Coil *a* is called the "primary" coil of the arrangement and coil *b* the "secondary" coil, when the relations are as described; in other words, the coil in which e.m.f. is induced is the secondary and the inducing coil is the primary.

If the current in the primary coil, *a*, be represented by *I*, and its number of turns be represented by N_1, the number of lines of force set up when the current is passing (if there be no iron in the magnetic circuit) will be $0.4\pi I N_1$, and if all of this flux cuts all of the turns of the secondary coil, *b*, it will induce an e.m.f. in that coil proportional (not equal) to $0.4\pi I N_1 N_2$; the actual e.m.f. induced will depend on the swiftness with which the flux cuts the wires, or, turning it about the other way, it will depend on the number of lines of force cut by the wires per second, exactly as in the case of the dynamo, the operation of which was described in a previous Lesson. It will be obvious that with two coils wound on a common iron core, a very high e.m.f. can be induced in one of them by giving that one a very large number of turns, while the primary or inducing coil may have a relatively small number of turns, provided a considerable current be passed through it so as to magnetize the core properly. This principle is made use of when it is desirable to obtain very high voltages and small currents from a source yielding low voltage and fairly large currents. The apparatus for thus changing by induction a current of one character into one of different character is known as an "induction coil."

A partial sectional elevation of an induction coil is shown in Fig. 7. A primary coil, *P*, which consists of two or three layers of coarse insulated wire, is wound upon a core, *C*, of soft-iron wires, which has been previously wrapped with several layers of insulating material. Over this is slipped a thick tube, *T*, of hard rubber, upon which a secondary coil, *S*, of a great many turns of fine well-insulated wire is wound. A battery, *B*, is connected in series with the primary circuit through a vibrating interrupter, *I*, which alternately closes and opens the circuit at *G*. The ends of the secondary winding are connected to two brass balls, *D*, *D*, between which a fine stream of sparks passes when the interrupter is vibrating rapidly.

For ordinary induction coils, the interrupter is usually arranged as shown diagrammatically in Fig. 8. Mounted on the end of a thin steel spring, *s*, is a soft iron piece, *a*. Normally, the spring rests against the end of a screw, *d*. Current from a battery, *b*, passes to the primary winding of the induction coil through this screw and spring, as the diagram clearly shows, and magnetizes the core, *c*, of the induction coil. The end of the core thereupon attracts the armature, *a*, and pulls the spring, *s*, away from the screw, *d*; this, of course, breaks the circuit between the battery and the coil, and the core is instantly demagnetized, releasing the armature and allowing the spring to fly back against the screw and close the circuit again, when the operation just described is repeated. Every time the circuit is closed the magnetism set up in the core induces an e.m.f. in the secondary winding, and every time it is broken, the magnetic lines of force collapse and thereby induce a second e.m.f. in the secondary winding, this time in the contrary direction, however. This goes on as long as the battery is connected to the coil and interrupter; and the vibrations of the latter occur many times per second, so that the successive e.m.f's induced in the secondary follow each other so rapidly as to produce an almost continuous effect. These e.m.f's are so high that a stream of sparks passes between the terminals, as previously stated. The distance across which the secondary winding can project its stream of sparks is the usual measure of the strength of the apparatus; thus, it is customary to speak of a "three-inch induction coil," a "six-inch coil," and so on, meaning that the coil will discharge a spark or stream of sparks across an air-gap of three inches, six inches, etc.

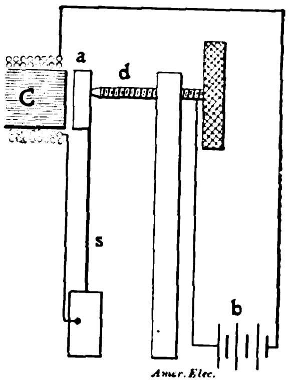


FIG. 8.—DIAGRAMMATIC ARRANGEMENT OF INTERRUPTER.

In order that the core of an induction coil may respond promptly to the rapid magnetizing and demagnetizing influences, it is always made up of small iron wires. The effect of the thickness of an iron core upon its magnetic responsiveness has already been explained in a previous Lesson.

Below is given a table of useful data for induction coils, which was compiled by Mr. Norman H. Schneider from modern practice:

Data for Induction Coils.

Spark lengths.	½ in.	1 in.	2 ins.	6 ins.	12 ins
Core length......	5"	7"	9"	12"	19"
Core diameter ...	⅝"	¾"	1"	1⅛"	1½"
Core wire size B. W. G.	22	22	22	22	22
Primary size B.&S.	16	14	14	12	10
Layers of primary	3	3	2	2	2
Secondary size B. & S.	36	36	36	36	38
Quantity in lbs. of secondary wire .	¾	1¼	2½	7	12

Letters on Practical Subjects

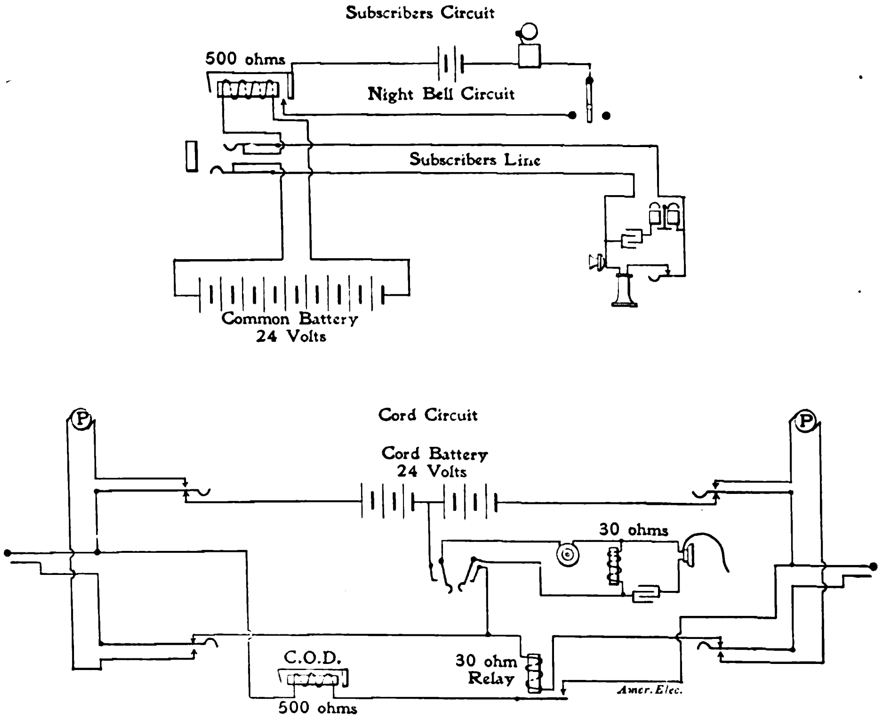
A Small Common Battery Exchange.

To the Editor, American Electrician:—

In a great many instances small magneto exchanges are installed where common battery systems would give a much smoother and more up-to-date class of service. This is particularly true of private installations. The system herein described is of very simple design and devoid of all unnecessary apparatus.

The current supply, both for the line signals and cord circuits, is furnished by dry batteries. The subscribers' signals are all operated from the common battery, which should consist of a sufficient number of cells in series to give 24 volts pressure at the terminals. Each cord circuit has its individual battery of 24 volts.

The subscriber's circuit is shown with a night bell attachment. The line signal in this case is wound to 500 ohms resistance, and is self-restoring. It will be seen, by tracing this circuit, that as soon as the subscriber takes his receiver off the hook his line signal will be operated by the common battery.



SMALL COMMON BATTERY TELEPHONE EXCHANGE.

In the cord circuit shown, it is possible to ring or talk from the operator's set over each plug. The cord battery of 24 volts is cut in series, as is also a 30-ohm relay in the cord circuit. It will be noticed that the operator's tap is located in the middle of the battery so as to enable the set to receive a flow of current while talking over each cord. The 30-ohm impedance coil is inserted in the operator's set in order to furnish a circuit for the transmitter current, as the receiver has a condenser cut in series with it.

The system operates as follows: As soon as two connected subscribers take off their receivers a flow of current occurs over the cord circuit and through the telephones. This causes the relay to close its contact and display the 500-ohm clearing-out signal, which is operated by the cord battery also. This signal will remain displayed until the circuit is opened by the replacing of a receiver, when the flow of current through the relay is stopped, causing it to release its contact and thus operating the clearing-out signal.

The dry cells used in such installations should be thoroughly shellacked or paraffined so as to keep them impervious to moisture. The different cord batteries should be so placed as to be readily accessible for repairs and inspection.

Chas. H. Coar.

Minneapolis, Minn.

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Electric Bell Connections.

To the Editor, American Electrician:

I should like to ascertain whether or not it is possible to connect two ordinary vibrating bells, two push-buttons and a single battery in such a manner that the push-button at one end of the line will ring the bell at the other end, and *vice versa.* Only two conductors must be used between the two stations, either a two-wire metallic circuit without any ground connection, or a single wire with ground return. If any of your readers know of a method by which this can be accomplished I will appreciate the publication of the method in this department.

Martin Smith.

New York.

[The results mentioned are possible by using a battery just strong enough to ring one bell when the other one is cut out of circuit, but not strong enough to affect either bell when both are in circuit; each push-button would then be connected to short-circuit the home bell when depressed. Such an arrangement is obviously more academic than practical, and it is mentioned in order to save our younger readers the discouragement of working it out, only to be told this afterward.—Editor.]

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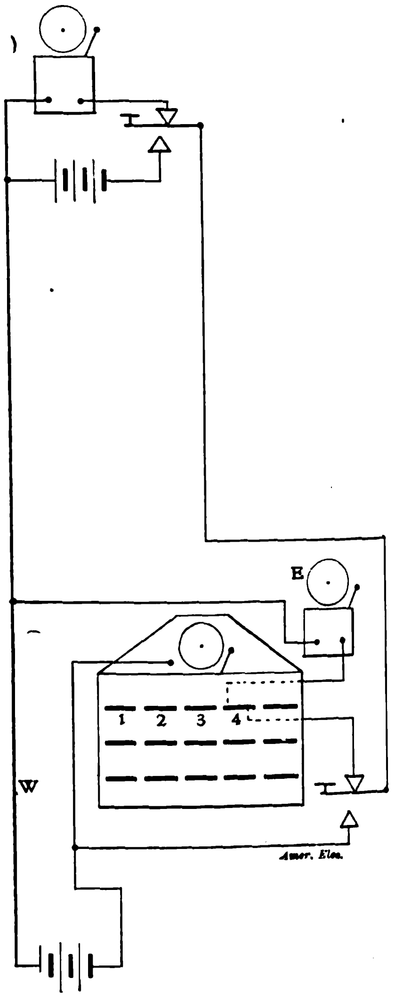
Mr. Isbell's Solution of Mr. Petry's Problem.

To the Editor, American Electrician:

I have just noticed that my second solution of Mr. Petry's problem is erroneous in that it bars the use of any other push-buttons in connection with the regular annunciator battery in the basement. I enclose a substitute solution, in which this defect is eliminated by the use of an auxiliary bell *E*, near the annunciator. The connections of drop No. 4 are entirely independent from the remainder of the annunciator circuits, as indicated by the dotted lines.



MR. ISBELL'S SOLUTION.

A. A. Isbell.

October 25, 1903.

[The foregoing communication was received before the November number of the American Electrician was issued, but too late for the changes to be made in that number.—Editor.]

Queries and Answers

IMPORTANT.—No attention will be given to any inquiry which does not give the full name and address of the inquirer.

Is it possible to transform from two phases to three with transformers of the ordinary type having equal ratios of transformation? C. I. McC.

No.

Will a ground on the secondary distribution of a transformer system show on ground detectors connected to the primary part of the system? H. A.

No.

Can the variable-voltage transformer described last month be used for bell and annunciator work? J. F. V.

Not unless the bells and annunciator drops are especially wound for alternating current, and such a system is not a commercial one.

Why is the neutral wire of a direct-current 220-volt system grounded throughout the system? C. W. P.

In order to reduce the maximum possible voltage between any live part of the system and any external grounded object to 110 volts.

What difference should be made in the primary winding of the variable-voltage transformer described last month, in order to adapt it for 114 volts instead of 100 volts at the primary? H. H. P.

No change is strictly necessary, but as a matter of precaution one size smaller wire may be used, putting on 1250 turns.

What is meant by the term "static transformer"? D. P. I.

This is a misleading name sometimes applied to the ordinary stationary transformer; while the term "static" is correct etymologically, it is ill-advised because it tends to suggest electrostatic apparatus, and the transformer does not come within this category.

A 30-volt fan motor is wound with No. 22 wire in the armature and No. 19 wire in the field. How should the windings be changed to make the machine run on an 8-volt circuit? C. M. P.

Rewind the armature with No. 16 wire, putting on one-fourth the present number of turns per coil, and rewind the field with No. 13 wire, putting on one-fourth the present number of turns in each coil.

When the polarity of a direct-current generator becomes reversed, what is the best method of restoring it to its original polarity? H. H. T.

Lift the brushes of the machine from the commutator and then connect it by means of its main switch to a direct-current circuit of the proper voltage, making the connections such that the magnet will be polarized in the proper sense.

Is the output of a two-phase generator the sum of the power values in the two circuits, or is it the sum of these values divided by $\sqrt{2}$? P. M. B.

It is the sum of the two values. Representing the current per phase by I, the e.m.f. by E, and the power factor by p, if the two circuits are exactly balanced the total output will be $2 \times E\,I\,p$.

What is an anti-logarithm? (2) Are common and natural logarithms identical? W. O. J.

An example will explain more clearly than a definition. The logarithm of 2 is 0.30103; therefore, 2 is the anti-logarithm of 0.30103. (2) No. Natural logarithms are identical with Napierian or hyperbolic logarithms, the base of which is 2.71828. Common or Briggsian logarithms have 10 as the base.

In trying to operate a No. 4 Porter motor as a dynamo I am unable to get more than 3 volts from the machine, although it is built to run as a motor on 110 volts. What is the trouble and how can it be remedied? C. P. G.

You cannot expect a motor driven as a dynamo to generate the same e.m.f. as that of the circuit on which it runs as a motor, if the speeds are the same in both cases. You can increase the e.m.f. of the machine by driving it at a higher speed.

When the Hylo double-filament lamp is screwed firmly into the socket both filaments are connected to the circuit, but the 16-c.p. filament produces light when the 1-c.p. filament does not. Why is this? F. E. B.

Your statement is inaccurate; when the lamp is screwed firmly into its socket only the 16-c.p. filament is connected to both sides of the circuit. One terminal of the baby filament is connected to one side of the circuit, but the other terminal is free.

A multipolar automobile motor gives trouble by blackening on the commutator. Immediately after the commutator has been sandpapered, two small black streaks begin to show on opposite sides of the commutator. These streaks gradually grow until they come together and make the whole surface black and dirty. When this condition is reached the power of the machine is reduced. What is probably the cause of the trouble? W. C. R.

The only cause that can be attributed without an examination of the machine is poor quality in the carbon brushes or the presence of some objectionable ingredient in their composition.

Can I operate in parallel a compound-wound direct-current dynamo having its series field winding shunted so that the voltage is 125 both at no load and at full load, and a slightly smaller machine of the same make compounded to give 110 volts at no load and 125 volts at full load? The smaller machine has no shunt on its series winding. T. O'C.

Remove the shunt from the series winding of the larger machine and ascertain what degree of compounding is obtained without it. If it is the same as that of the smaller machine, then the two can be operated in parallel without trouble. If it is greatly different, they cannot.

What will be the synchronous speed of a six-pole three-phase induction motor with the stator winding connected in mesh and supplied from a circuit giving 110 volts and 60 cycles? E. S. L.

The number of phases and the method of connecting the winding have no effect upon the synchronous speed. The synchronous speed of both induction and synchronous motors is given by the formula:

$$120 \times f \div P = r.p.m.$$

in which f is the frequency in cycles per second and P is the number of poles; for an induction motor it would represent the number of poles per phase.

If a 220-volt 40-hp. motor, located one mile from a source of current, be supplied by a line consisting of No. 00 wire, what will be the drop in the line and how is it computed? L. E. A.

The fundamental formula is as follows

$$\frac{22\,I\,D}{d^2} = v,$$

in which I is the current, D is the distance in feet, d^2 is the circular mils of the wire, and v is the drop in volts. A 220-volt, 40-h.p. motor will take approximately 150 amperes. The cross-section of No. 00 wire is 133,100 circular mils and the distance is 5,280 feet; the drop, therefore, would be approximately 130 volts, so that the arrangement would be hopelessly impractical.

What are the Underwriters' requirements as to the thickness of rubber insulation on electric light wires and slow-burning weather-proof insulation on the same class of work? (2) Is a slow-burning weather-proof insulation allowed indoors on 500-volt circuits? R. C. C.

On Nos. 16, 17 and 18 rubber-covered wire the insulation must be 1/32 inch thick; on Nos. 8 to 15 wire, 3/64 inch thick; on Nos. 2 to 7 wire, 1/16 inch thick, and on Nos. 0000 to 1 wire, 5/64 inch thick. The thicknesses are the same for slow-burning weather-proof insulation, but wires smaller than No. 14 are not allowed with this insulation. (2) Yes, for open work in dry places. Open work in damp places and all other classes of wiring must be done with rubber-insulated wire.

What is meant by the cylinder ratio of an engine? (2) What is three-stage expansion in an engine? C. W. T.

The cylinder ratio is the ratio of the low-pressure cylinder area to the high-pressure cylinder area in a compound engine. There are two cylinder ratios in a triple-expansion engine—that of the low-pressure cylinder area to the intermediate cylinder area and that of the intermediate to the high-pressure cylinder area. (2) Triple expansion; that is to say, the steam is expanded in three separate operations or stages—once in the high-pressure cylinder, again in the intermediate cylinder, and a third time in the low-pressure cylinder or cylinders.

What resistance should be used in series with a storage battery of 48 cells, divided into two parallel groups of 24 cells each, to charge the battery from a 110-volt dynamo? H. B. R.

This depends upon the proper charging current for the battery. Divide 30 by the rated charging current per cell and the result will be the resistance in ohms that you will need in series with the two groups at the beginning of the charging; some of the resistance must be cut out as the charging progresses and the e.m.f. of the battery rises. It is extremely poor practice, however, to charge through a resistance when you can connect your cells all in series and charge them directly without any intervening resistance by adjusting the dynamo e.m.f.

What is the candle-power and voltage required for the small lamps used for decorating Christmas trees, etc.? (2) Can a Christmas tree outfit of these lamps be supplied from storage batteries, and if so, what capacity should the batteries have for four hours' operation? F. S.

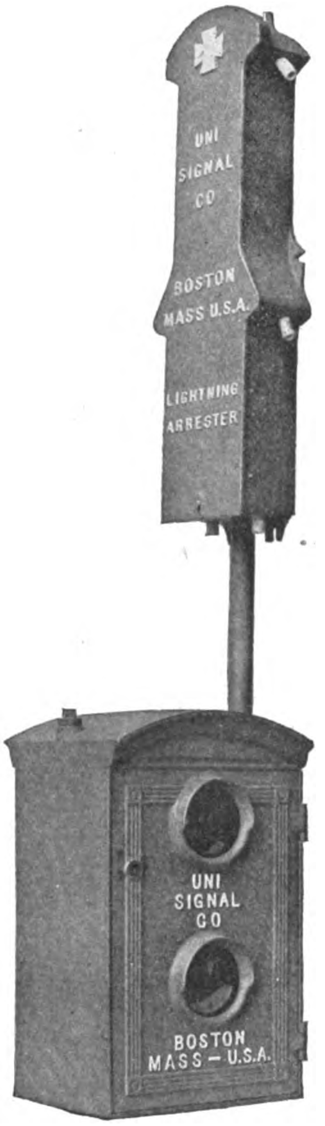
From 1 to 2 candle-power and from 4 to 8 volts, according to the arrangement of the lamps and the source from which they are supplied. A convenient arrangement consists of 28 1-c.p. lamps in series, supplied from an ordinary 110-volt incandescent circuit. Such a string would require about ½ ampere. (2) This is possible, but the arrangement just described is much preferable. If storage batteries must be used, it will be better to use lamps requiring one volt each and connect them in groups of 8 or 10 in series. A 1-volt miniature lamp will require from 2 to 2½ amperes. The battery should be proportioned for the total amperage on the basis of its 8-hour discharge rate.

AUTOMATIC BLOCK SIGNAL SYSTEM FOR STREET RAILWAYS.

The accompanying illustrations show the details of a standard automatic, non-interfering, two-line wire block signal system which is applicable to any electric railway system, and is especially adapted for single track trolley lines. Three methods of blocking are employed; these are known as types *A*, *B* and *C*, and a diagrammatic sketch of each is given in Fig. 3.

In Type *A* the trolley switches are located at each end of the section of single track between the turn-outs or sections of double track. The switches are double acting; that is to say, they light in one direction and extinguish in the other. The signal boxes are set in the customary location, one pole stretch in advance of the trolley switches. Two double acting trolley switches are required with this type, together with two terminal boxes with lightning arresters, and two signal boxes per block. A disadvantage of this type, however, is that it is impossible for a car to back out of the section with its trolley on the wire without extinguishing the signal set by the car entering the other end of the block. The signal may remain set, however, if the car should coast with the trolley down when passing under the trolley switch when backing out of the section.

In Type *B* the switches are located on the turn-outs or double tracks, and not on the single-track trolley. The switches are single-acting and will only light or extinguish as respectively arranged for. This requires that the cars shall pass under the trolley switch going in the proper direction to make the switch operative. Four single-acting trolley switches are required with this type, together with two terminal boxes with lightning arresters, and two signal movements and boxes per block. This type possesses the advantage that a car can back under the trolley switch without extinguishing the signal set by a car already in the block. A disadvantage, however, is that four trolley switches are required and cars can only take the turn-outs in one fixed and predetermined direction.



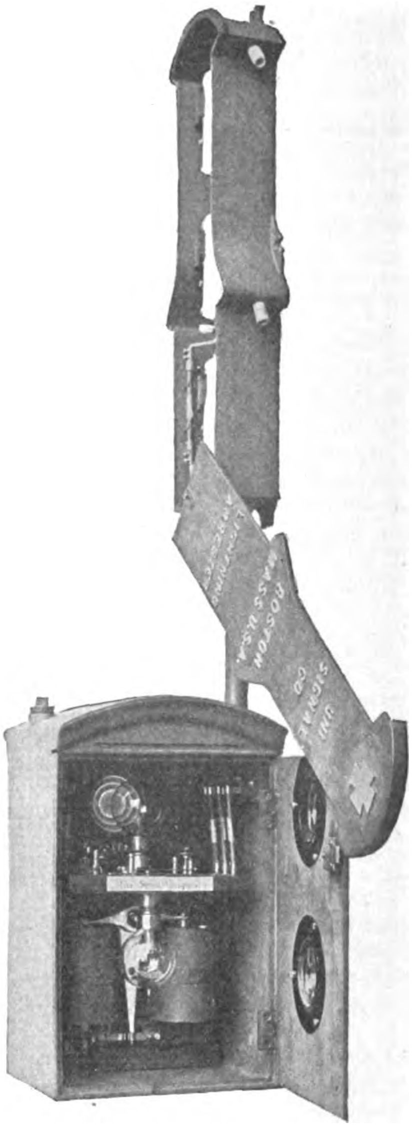


FIG. 1.—VIEWS OF SIGNAL BOX.—FIG. 2.

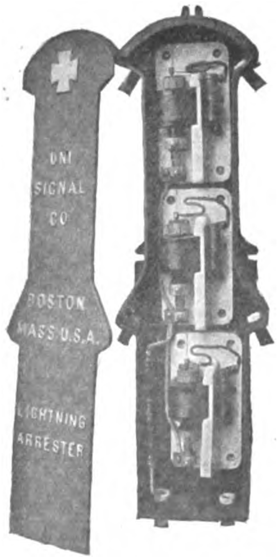


FIG. 4.—LIGHTNING ARRESTER.

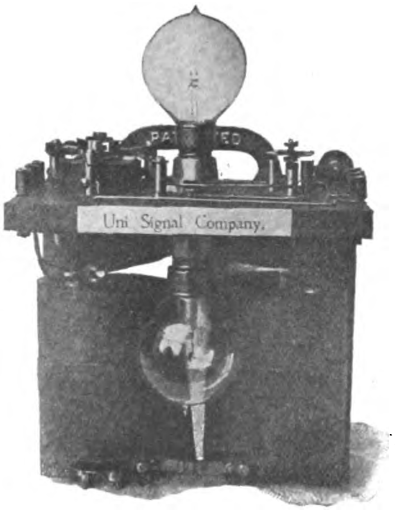


FIG. 5.—SIGNAL MECHANISM.

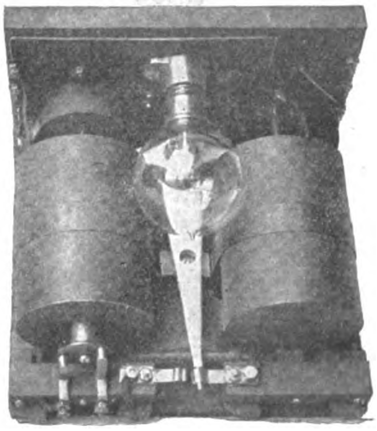


FIG. 6.—SIGNAL MECHANISM.

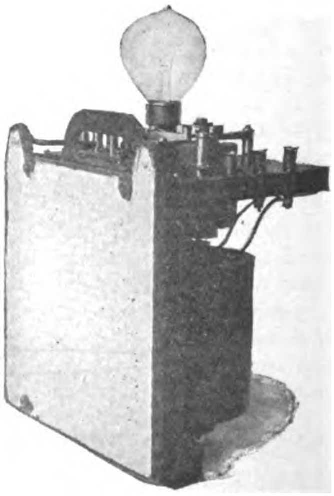


FIG. 7.—REAR VIEW OF SIGNAL MECHANISM.

Type *C* represents a combination of Types *A* and *B*, and can be used to meet special conditions of road and travel. The application of this type is self-evident from the descriptions of Types *A* and *B*. The standard equipment for a complete block comprises two signal movements, two iron signal boxes, two double-acting trolley switches, and two terminal boxes, each containing three lightning arresters.

Clamped to the trolley wire, and supported by a span wire from the nearest pole or by a bracket arm, is installed the trolley switch at a point as near to the bifurcation of the single section of track as practicable. On the pole nearest in advance to that supporting the trolley switch is located the signal box, and directly above it is installed the terminal box containing the lightning arresters.

The signal box is attached to the pole so as to show both the green and red signal lamps of the trolley switch at the entering end of the block. From the trolley switch are run two switch wires to the adjacent terminal box containing the lightning arresters, and which in turn connects with the signal box by heavy insulated rubber-covered wires. The two signal boxes are connected together through their respective terminals by two signal line wires. Each signal box likewise has a permanent feed wire connection with the trolley wire and one with the track; thus six wires enter the terminal box. These wires are known respectively as the lighting switch wire, extinguishing switch wire, lighting line wire, extinguishing line wire, the permanent feed wire, and ground wire.

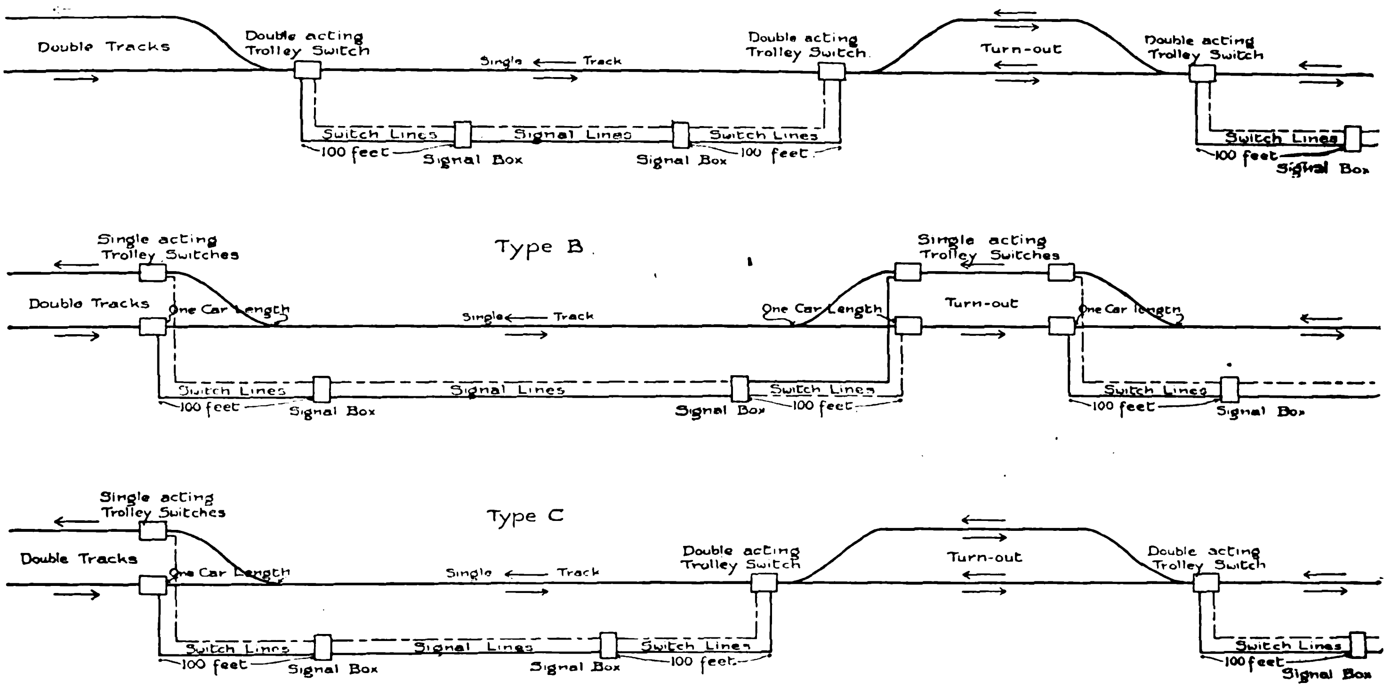

Double Tracks
Double acting Trolley Switch
Single ← Track
Double acting Trolley Switch
Turn-out
Double acting Trolley Switch
Switch Lines
Signal Lines
Switch Lines
Switch Lines
100 feet
Signal Box
Signal Box
100 feet
100 feet
Signal Box
Single acting Trolley Switches
Type B
Double Tracks
One Car Length
Single ← Track
One Car Length
Single acting Trolley Switches
Turn-out
One Car Length
Switch Lines
Signal Lines
Switch Lines
Switch Lines
100 feet
Signal Box
Signal Box
100 feet
100 feet
Signal Box
Single acting Trolley Switches
Type C
Double Tracks
One Car Length
Single ← Track
Double acting Trolley Switch
Turn-out
Double acting Trolley Switch
Switch Lines
Signal Lines
Switch Lines
Switch Lines
100 feet
Signal Box
Signal Box
100 feet
100 feet
Signal Box

FIG. 3.—TYPICAL METHODS OF BLOCKING.

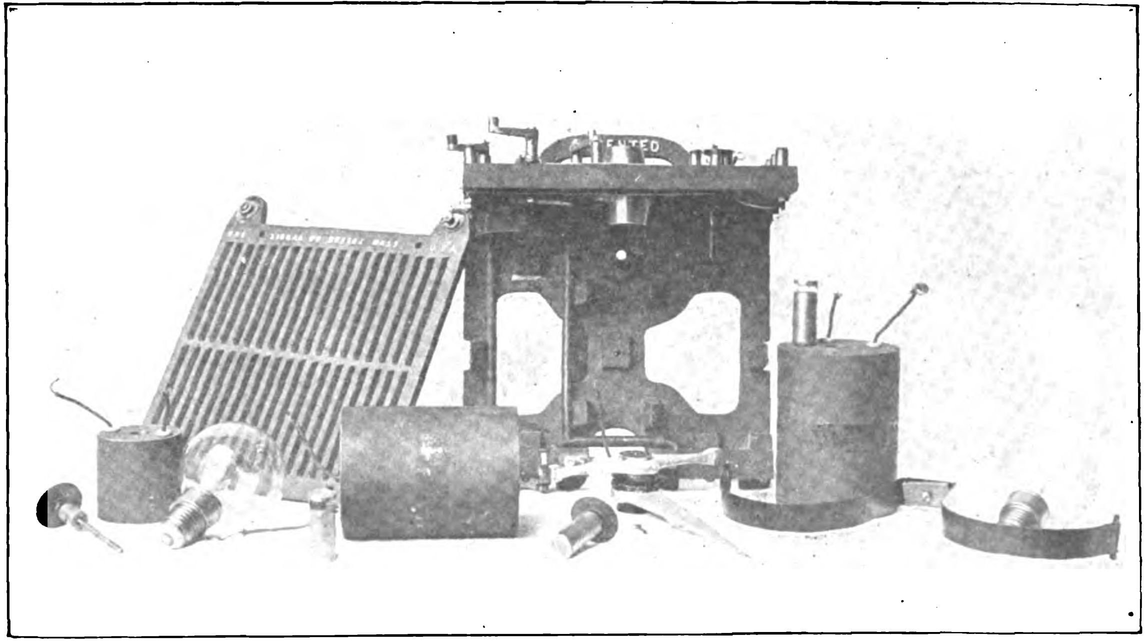


FIG. 8.—COMPLETE DETAILS OF SIGNAL MECHANISM.

In operation a car entering a section lights a green lamp in the signal box directly in advance of it, and also lights a red lamp wired in series with it in the signal box at the other end of the block. When the car passes under the switch at the leaving end of the block, both lamps are extinguished. When neither lamp is lighted the section is clear. When a car has once entered a block and set its signals, another car following will not affect the signal, nor would a car coming in the opposite direction and running under the trolley switch with the danger signal set against it. The signal can only be restored, when once set, by running under the leaving end trolley switch in the proper direction. Loss of current from the trolley will extinguish the signal lamps, but these will relight again as soon as the circuit is established. Should a lamp burn out after the signal is set, thereby destroying a visual signal, it will be impossible for another car coming in either direction to secure a signal.

Figs. 2 and 9 show one-half of the equipment of a complete block section. This comprises the signal box and movement, the terminal box with lightning arresters, and the trolley switch. The front of the box (Fig. 1) shows the two signal lights, the safety lamp or green light being at the top and the red or danger light at the bottom. Fig. 2 shows the green signal on the other side of the box. The signal box being located on the side of the pole, it is evident that the green or safety lamp shows in both directions if the signal has been set by an entering car, while the red lamp can only be seen while approaching a signal box if the block is already occupied by a car entering at the other end. Fig. 4 shows the terminal box cover removed, exhibiting to view the three lightning arresters which are furnished with each box. The heavy fuse wire in the leg to ground is also seen at the lower left-hand corner. The porcelain tubes where the wires enter the terminal box are also clearly shown, as well as the lugs for attaching the box to the pole. By simple loosening the screw at the bottom of the box and slightly lifting the cover, the cover may be swung open without detaching it from the box, as shown in Fig. 2, which also shows the signal box with the door open and the movement in place. By simply turning a lock button in the back of the box and removing the enclosed fuses at the side of the movement the entire signal movement can be removed from the box by the handle cast integral with the back plate.

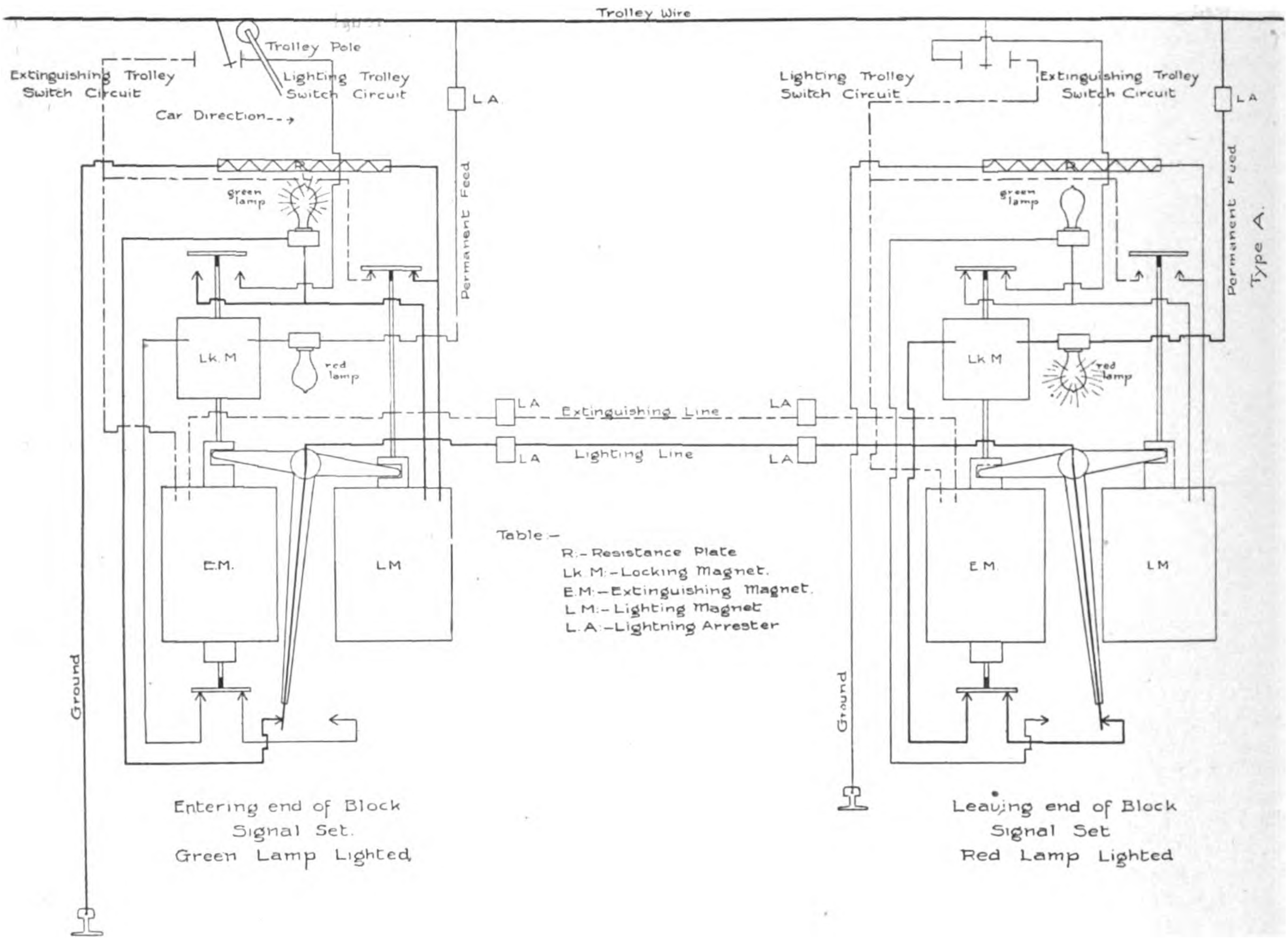
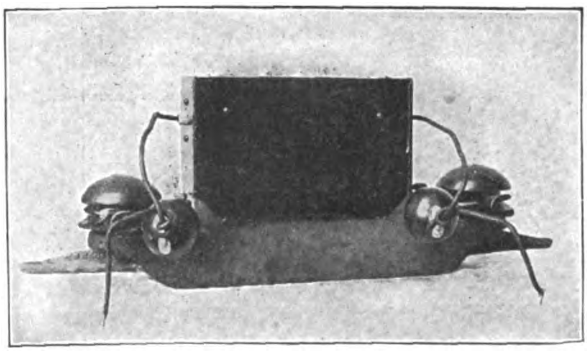

Trolley Wire
Trolley Pole
Extinguishing Trolley Switch Circuit
Lighting Trolley Switch Circuit
Car Direction-->
L A
Permanent Feed
R
green lamp
Lk. M
red lamp
L A
Extinguishing Line
L A
Lighting Line
L A
L A
E.M.
L M
Table:-
R.- Resistance Plate
Lk M:-Locking Magnet.
E.M:-Extinguishing Magnet.
L.M:-Lighting Magnet
L.A:-Lightning Arrester
Ground
Entering end of Block Signal Set. Green Lamp Lighted
Lighting Trolley Switch Circuit
Extinguishing Trolley Switch Circuit
L A
Permanent Feed
Type A.
R
green lamp
Lk M
red lamp
E M
L M
Ground
Leaving end of Block Signal Set Red Lamp Lighted

FIG. 11.—DIAGRAMMATIC SKETCH OF COMPLETE BLOCK SIGNAL USING DOUBLE-ACTING TROLLEY SWITCHES.



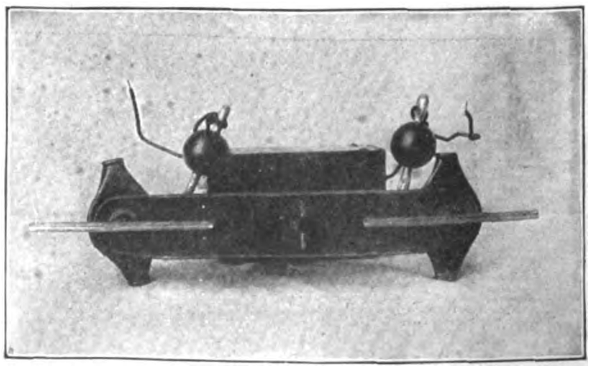


FIG. 9.—SIDE AND BOTTOM VIEWS OF TROLLEY SWITCH.—FIG. 10.

The movement is shown in Figs. 5, 6 and 7. Fig. 5 is a front view of the movement, showing the three magnets, the switch aluminum lever and balance arm, the signal lamps, and the two circuit-breaking contacts located on the top slate. The third circuit-breaking contact in the box is shown at the bottom of the left-hand magnet in Fig. 6. Fig. 7 shows the rear view of the movement, illustrating the manner in which the resistance plate is attached to the three brass lugs mounted on the slate of the movement.

Fig. 8 shows the iron back plate and bottom slates, while at the left-hand side of the back plate are seen the two fibre tubes enclosing the connection between the top and bottom slates. Resting at the left of the back plate is a ribbed iron resistance plate having large capacity. In front of the back plate is the aluminum lever and balance arm, while standing at the right side is the lighting magnet with its armature. Lying on its side at the left of the back plate can be seen the extinguishing magnet with its two armatures. To the left of this is the small locking magnet with its armature and disc contact. At the extreme right is the iron strap which holds the large magnets in place.

Fig. 9 shows the trolley switch, and Fig. 10 is another view bottomside up. The cover is made of iron with lapped joints, and is then galvanized and japanned. The main body is of malleable iron. The supporting frame is cast in one piece and holds all of the operating parts of the switch, as well as the top slate for the contact springs. When the hood is placed in position, contact is made between the two flat springs on the top slate and two brass plates at the top of the hood also mounted on the slate. The time-element device is very simple, but is effective, experience having shown that the circuit is broken in the box by the main movement rather than in the trolley switch itself.

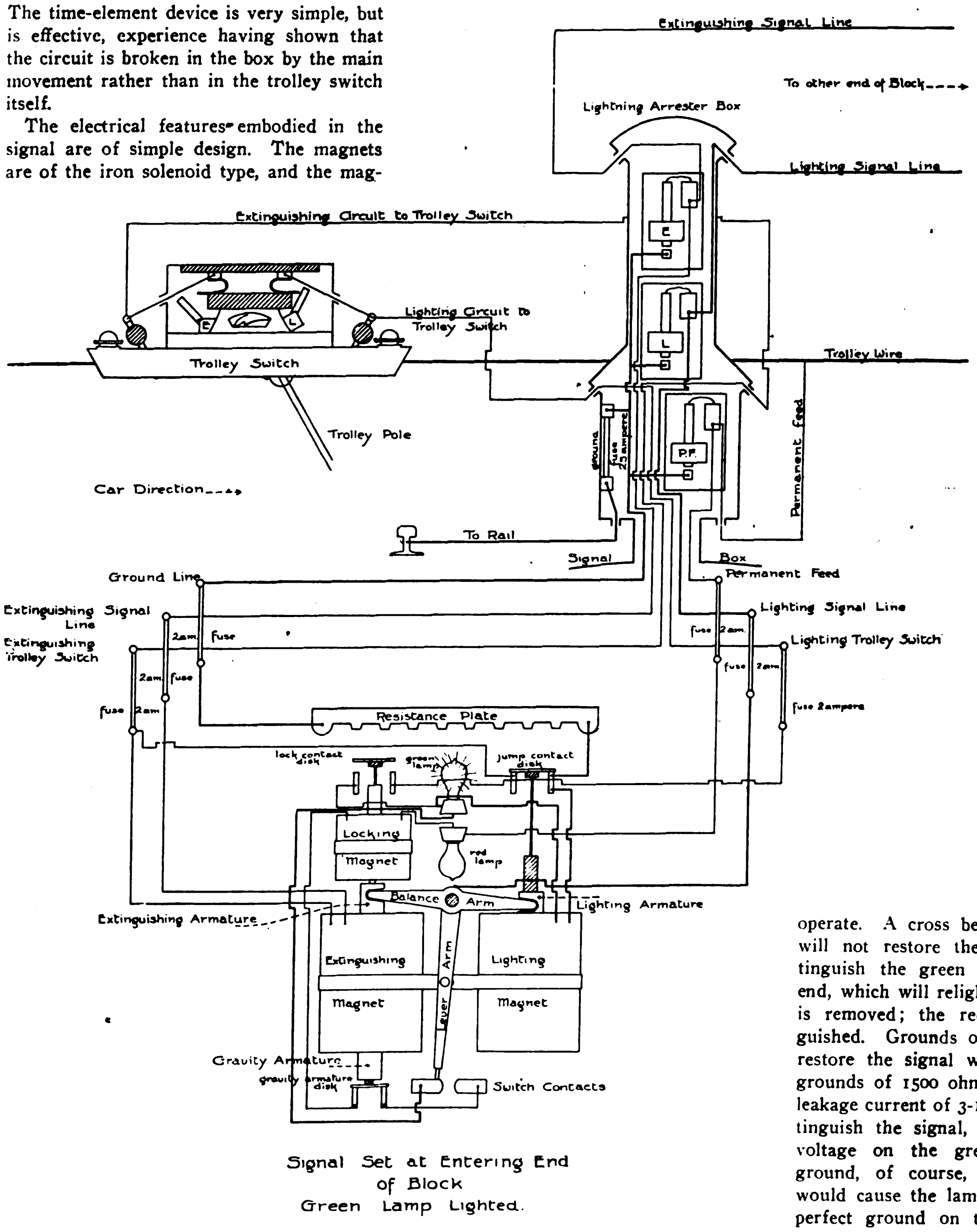

Extinguishing Signal Line
To other end of Block
Lightning Arrester Box
Lighting Signal Line
Extinguishing Circuit to Trolley Switch
E
L
Lighting Circuit to Trolley Switch
Trolley Switch
Trolley Wire
Trolley Pole
Ground
Fuse 25 ampere
P.F.
Permanent Feed
Car Direction
To Rail
Signal
Box
Permanent Feed
Ground Line
Extinguishing Signal Line
Extinguishing Trolley Switch
2am
fuse
Lighting Signal Line
Lighting Trolley Switch
fuse 2 ampere
Resistance Plate
lock contact disk
green lamp
jump contact disk
Locking Magnet
red lamp
Balance Arm
Lighting Armature
Extinguishing Armature
Extinguishing Magnet
Lighting Magnet
Lever Arm
Gravity Armature
gravity armature disk
Switch Contacts
Signal Set at Entering End of Block Green Lamp Lighted.

FIG. 12.—DIAGRAM OF CONNECTIONS FOR STANDARD TWO-WIRE AUTOMATIC BLOCK SIGNAL.

The electrical features embodied in the signal are of simple design. The magnets are of the iron solenoid type, and the magnet coil is wound on a brass spool, insulated by oiled silk. In series with the red lamp is the locking magnet, which is energized, of course, as soon as any current passes through that lamp. This holds the armature core against the locking magnet, and at the same time a tail rod connected with the armature presses against the balance arm of the movement and prevents the lighting magnet from operating, the object being to prevent the extinguishing of the red lamp signal should a car attempt to enter a block with the red signal set against it. All of the circuit-breakers in the box are of the double-break disc type. A single switch lever is provided for changing the connections in the box, but this breaks no live circuits and, therefore, cannot cause trouble. There are no springs in the entire movement, gravity or magnetic pull being the source of motion in all cases.

The system, the wiring of which is shown diagrammatically in Fig. 11, operates as follows: When a car enters the block it causes current from the trolley wire to pass through the lighting magnet and resistance plate to ground at that end. This causes the switch lever to be thrown over to the left-hand contact of the switch, thus causing current to be taken from the leaving end of the block, passing through the red lamp, locking the magnet at that end, and then through the lighting signal line to the entering end, where it traverses the green lamp and resistance plate and passes to ground. To extinguish the signal, current is taken from the trolley at the leaving end of the block through the extinguishing magnet at that end, then through the extinguishing line to the entering end and then through the extinguishing magnet at that end, passing to ground through the resistance plate. It might appear at first sight that there would be current through both magnets at the entering end and under such circumstances impossible for the switch lever to be restored to its normal position. Observation, however, shows that as soon as the current is established in the extinguishing circuit the gravity armatures are raised and the one in the leaving end of the block cuts the current off the lighting magnet in the entering box, thereby allowing the extinguishing magnet in that box to operate. A cross between the signal lines will not restore the signal, but will extinguish the green lamp at the entering end, which will relight as soon as the cross is removed; the red light is not extinguished. Grounds on either line will not restore the signal when once set. Three grounds of 1500 ohms resistance, giving a leakage current of 3-10 ampere, will not extinguish the signal, but slightly raise the voltage on the green lamp. A perfect ground, of course, on the lighting line would cause the lamps to burn out, and a perfect ground on the extinguishing line will not allow the signal to restore to its normal condition; in either case, however, faulty signals are impossible. The complete details of the wiring for a complete block, and the actual arrangement of the wiring for a switch terminal box, lightning arresters, and the signal movement, are shown in Figs. 11 and 12. The system is manufactured by the Uni Signal Company, of Cambridge, Mass.

POWER EQUIPMENT IN THE MEXICAN CENTRAL RAILWAY SHOPS.

The Mexican Central Railway Company, Limited, has consolidated all of its various shops along the lines of the company into one central and modern plant at Aguas Calientes, State of Aguas, Mexico, capable of doing all of the repairs and construction work of the company. he plant comprises over twenty shops and buildings, and has a yard area 120 acres in extent. A modern power house has been erected, containing three 300-h.p. De Laval steam turbines direct-connected to 200-kw. direct-current dynamos.

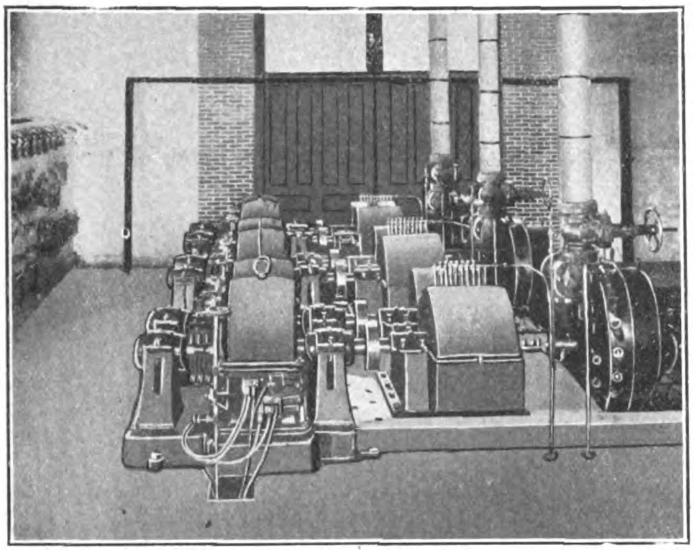


FIG. I.—GENERATING EQUIPMENT IN MEXICAN CENTRAL RAILWAY SHOPS.

Steam is supplied by three 250-h.p. Babcock & Wilcox boilers, generating steam at 200 pounds pressure and superheated 120 degrees Fahr. Two Sturtevant fans supply mechanical draft. The turbines are designed to operate condensing with 28 inches of vacuum. Each of the 200-kw. electric units consists of two 100-kw. generators mounted side by side and geared together by means of turbine pinion and two gears. They combine what would otherwise be two separate generator frames into one, at the same time leaving two openings in which the armatures revolve, and are splendidly adapted for operating on a three-wire system. The extended area covered by the various buildings made it expedient to operate on a 250-500-volt, three-wire system.

The condenser is of the surface type, provided with automatic hot well pump, as well as a rotative dry vacuum pump, a cooling tower being used to cool the circulating water. Two steam-driven air compressors furnish compressed air for operating pneumatic tools and for various other purposes throughout the shops and yards. In the power-house all steam, water and air pipes and electrical conductors are placed in ducts in the floor, which are covered with cast-iron plates. The condenser pit is bridged with a necessary passage which is flush with the floor.

The switchboard is constructed of blue Vermont marble and contains the usual equipment of Weston instruments and all necessary switches and circuit-breakers for the convenient operation of the plant, as well as a recording wattmeter, which measures the total power generated in the station. The erecting shop has two 60-ton, three-motor cranes which travel in the main span, and the bays on either side are furnished with single-motor cranes of 5 tons capacity. The location of the plant being remote from the shops of the manufacturers of the various apparatus, the feature of necessary repairs was given consideration, and every part of the plant was carefully planned with this in view. In order to minimize the stock of desirable wearing and repair parts, the least number of horse-power sizes of motors was selected. For this reason the group system of drive was generally adopted, although a number of new machine tools are installed with the most improved method of individual motor drive. The power is transmitted throughout the yards on insulated conductors carried on iron poles. All mains are carried to the centers of distribution located inside the buildings, and the lines leading from the centers to the individual motors are carried in steel conduit, which in most cases runs under the floor. All of the larger units are protected by circuit-breakers, while suitable fuses are provided for the smaller units. A complete equipment for chemically treating railroad ties is installed, and this is large enough to treat all the ties used on the system. This installation is equipped with the most modern machinery for treating timber so as to withstand the severe conditions met with in Mexico.

THE NEW WORTHINGTON PLANT.

An extensive pump manufacturing plant, the largest in this country, and probably in the world, is now under construction at Harrison, N. J. It is to be occupied by the firm of Henry R. Worthington, which employs about 3000 men in its works at Brooklyn, N. Y., and Elizabethport, N. J. The new plant at Harrison will accommodate from 4000 to 5000 men. It consists of a main machine shop, with side galleries over 1006 feet long, an erecting shop 592 feet long and of the same section as the machine shop, and a high erecting shop 210 ft. in length and four galleries in height in the side bays connecting the two shops. The main foundry is 600 feet in length and there is also a special foundry for small work, 410 feet in length, with a building 200 by 60 feet in size for cleaning castings connecting the two. The pattern building is four stories high and 550 feet long, and is divided by wire walls into four sections. The north section will be used for offices and drafting rooms, the adjoining section for the pattern shop and the balance of the structure for pattern storage.

The power house, which will be equipped with modern boilers, engines and generators, is a building 172 by 102 feet. Electric power distribution is to be employed throughout, and the grounds will be illuminated by electric arc lights. There are many other buildings which will be used for packing, storing and shipping goods, etc. The buildings are so arranged that additions can be built when the work demands it. All will be connected by a complete system of railroad tracks entering the ends of the buildings and placing the works in direct communication with the Delaware, Lackawanna & Western, the Erie and the Pennsylvania Railroad systems.

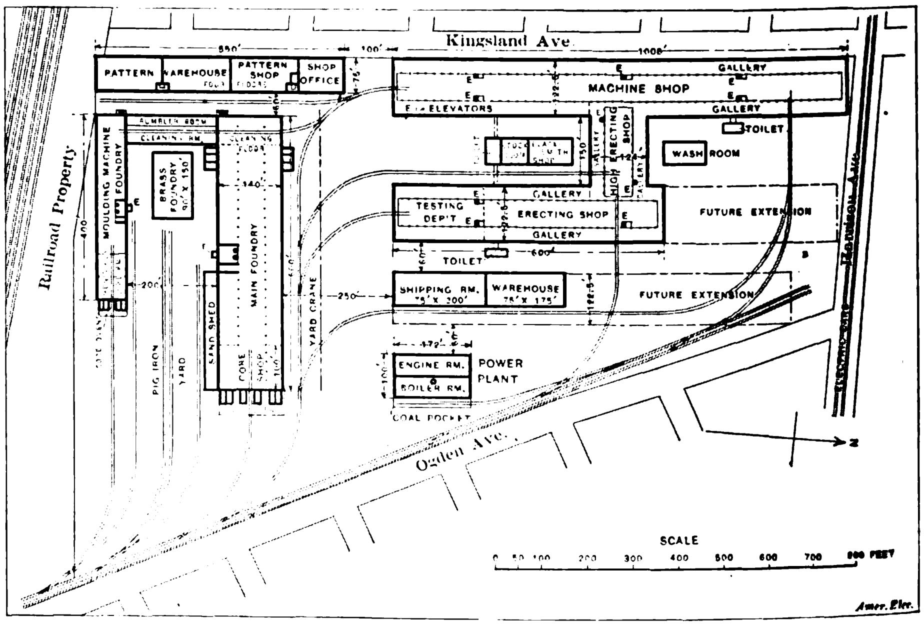


FIG. I.—PLAN VIEW OF THE NEW WORTHINGTON WORKS.

The new plant will be devoted entirely to the manufacture of water works machinery, water meters, cooling towers, condensers, feed-water heaters, centrifugal pumps and steam pumps of all kinds.

New Apparatus and Appliances

SPLIT CONDUIT FOR HIGH-TENSION STATION WIRING.

The protection of high-tension cables so that troubles in one cable will not spread to other cables when a short circuit occurs is being given an increasing amount of attention. In designing high-tension wiring for the stations and sub-stations of the Chicago Edison Co., Edward N. Lake had occasion to devise the special forms of split or divided tile illustrated herewith. By the use of this divided tile or conduit high-tension cables can be protected by conduit at many places where hitherto such conduit has been out of the question because of the impossibility of pulling cable into such crooked passages as would be necessary in the wiring around stations. Instead of being split with joints opposite, the split occurs above and below the center line, so that the joints of any one tile do not come opposite the joints of the next tile. There is thus a wall of vitrified tile between any two conductors, as the joints are never opposite. The tile is made in short lengths in curves, which would make it possible to cover and effectually isolate almost any short run of lead-covered cable found in high-tension station work. With this tile the practice of placing high-tension cables on racks in manholes and passage ways can be done away with entirely, and cables can be entirely isolated from each other with a wall of vitrified clay. The bends are 16 inch radius, 45 degrees in length, so that they cover 12½ inches of cable. They are made with both horizontal and vertical divisions, so as to be easily applied in different locations. In the accompanying drawing is shown a sample of the high-tension wiring now being done by the Chicago Edison Company, showing this divided tile of Mr. Lake's design. The high-tension cable from the static transformer to the oil switch on the floor above is entirely enclosed in vitrified conduit. The conduit is manufactured by the H. B. Camp Company, of New York, Pittsburgh and Chicago.

FIG. 1.—SPLIT CONDUIT.

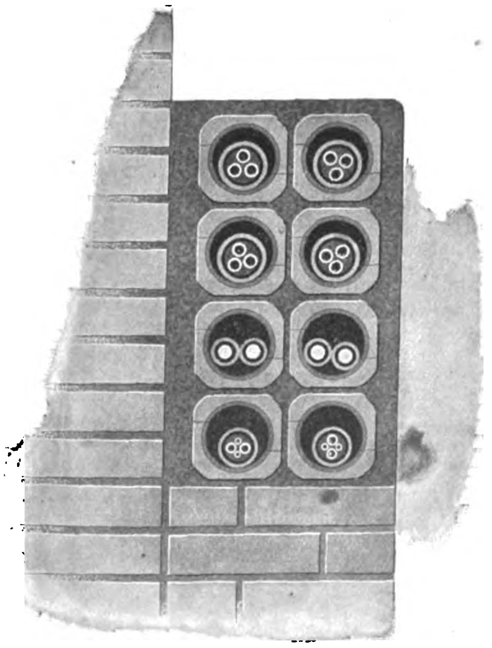


FIG. 2.—LAKE SPLIT CONDUIT.

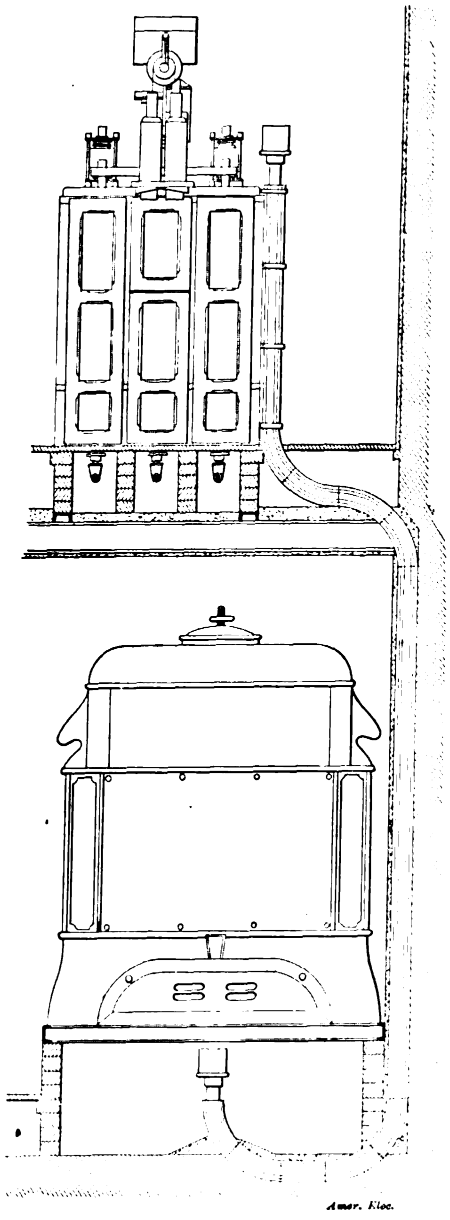


FIG. 3.—CONDUIT APPLIED TO HIGH-TENSION WORK.

THE LITTLE MAC SWITCH.

Where two sets of battery are used interchangeably in connection with the igniters for gas or gasoline engines, some sort of switch must be used to throw one set of batteries in, and the other out of service. A simple switch devised for this purpose has been brought out by the G. N. McKibbin Manufacturing Company, of South Norwalk, Conn., and is shown by Fig. 4 herewith. An arm of spring brass is riveted at one end through a brass piece forming a common terminal for both batteries. The other terminals are fastened at either end, and are of brass so shaped as to lock the arm so that it cannot be dislodged though any jarring. Two pegs serve to center the arm when it is desired to cut the batteries out of circuit and to hold it in that position. The wiping action of the arm serves to keep the contacts bright and clean.

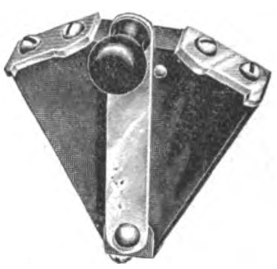


FIG. 4.—LITTLE MAC SWITCH.

TRUMBULL FLUSH RECEPTACLE.

The main features of the flush receptacle shown in the accompanying illustration, made by the Trumbull Electric Manufacturing Company, Plainville, Conn., are that it fits into any standard switchbox without the use of a special plug, and that it is made to take the ordinary Edison base attaching plug, such as is used for tapping into an incandescent lamp fixture for a fan motor or a desk lamp. In this respect the receptacle is claimed to be unique. Anyone using an Edison plug will doubtless find this device a convenience. It is fitted with a nickel-plated cover.

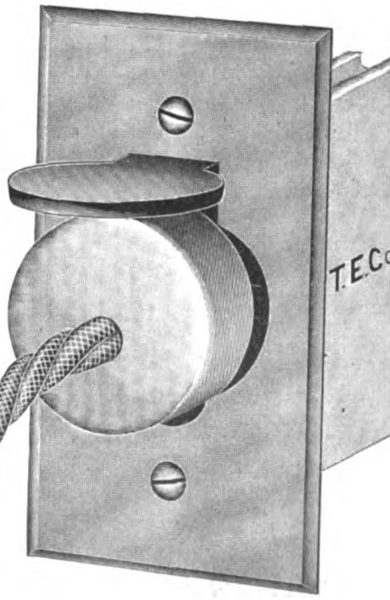


FIG. 5.—TRUMBULL FLUSH RECEPTACLE.

THE BATES METAL NUMBERING MACHINE.

The operation of numbering name plates and metal parts has, until recently, remained a most unsatisfactory one, and the system of employing individual figure stamps and hammer is not only crude, slow and expensive, but errors and irregularities constantly occur and the appearance of the work is far from attractive. The machines here illustrated, built by the Bates Machine Company, of New York, accomplish the work accurately, and any numbers which skip backward or forward, such as type and voltage numbers, may be impressed upon the parts themselves or upon plates or tags to be attached to them. The machine shown by Fig. 6 is intended for consecutive numbering upon castings, steel bars and plates, metal tags and the like. It may be operated in any punch, screw or lever press. The shank is made straight or to any taper or length desired. It is set up in the same manner as an ordinary punch, the stroke of the press being carefully adjusted to the depth of the impression required. As the disks revolve the figures are brought into correct alignment, are equally spaced and all are sunk the same depth, thus insuring uniformity. The lever bar may be attached to any stationary part of the press, and the numbers will then advance automatically, in consecutive order with each stroke. The figures and letters are made to any style desired and are cut upon tool steel hardened wheels.

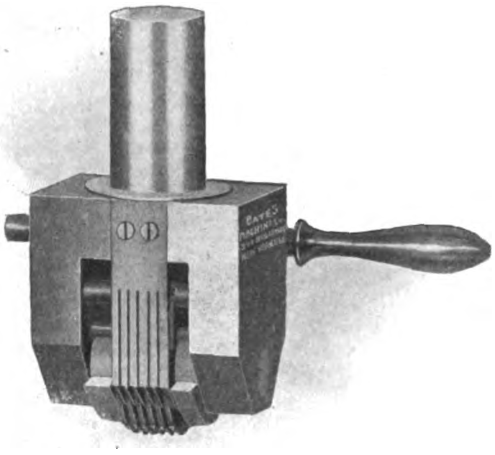


FIG. 6.—BATES NUMBERING MACHINE.

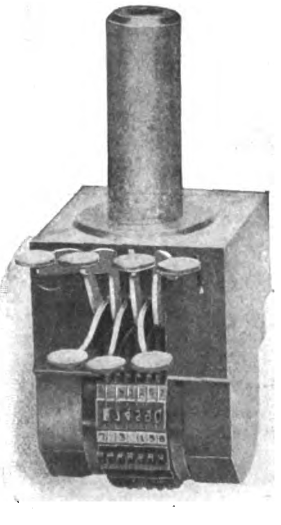


FIG. 7.—BATES NUMBERING MACHINE.

The device shown by Fig. 7 is intended for stamping the style, grade, amperes, voltage and power numbers upon parts of motors, dynamos, electric motors, etc. Any combination of letters and figures may be set—skipping backward or forward—as is required for numbers which do not progress consecutively. Each numbering wheel is provided with a lever, which operates it independently of the others. The ends of these levers form a small keyboard. The figures and letters which are in the stamping position are always shown by the indicators on the front of the wheels just below the keyboard.

In the hand lever bench press, Fig. 8 adjustable gauges are usually provided, to which the pieces to be numbered are fed. A toggle joint insures maximum power with comparatively slight pressure upon the lever.

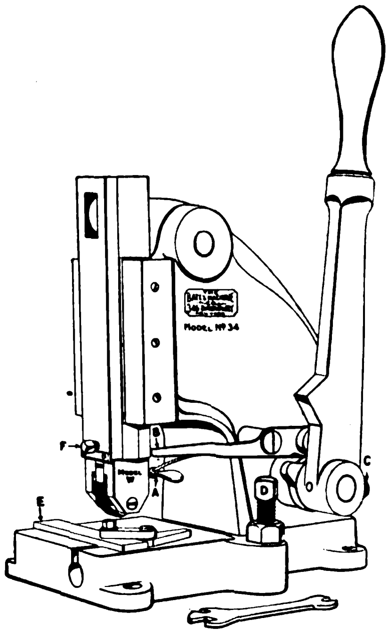


FIG. 8.—BATES NUMBERING MACHINE.

IMPROVED NERNST LAMP.

The Improved Electric Light and Supply Company, of New York City, has brought out a new Nernst lamp which differs in many respects from those now in use on this side of the Atlantic. The lamp resembles the German lamp made by the Allgemeine Elektricitäts Gesellschaft. Figs. 9 to 12 show the various parts. The automatic cut-out is placed immediately beneath the base, and the armature is attached to a spring normally holding it out of engagement, enabling the lamp to be placed in any position. The ballast is shown by Fig. 10. It is removable, and slides between two guides, which hold it in position and also form electrical connection with it through the two brass contacts shown at the sides. The glower is shown by Fig. 11. As is well known, in order that the life of a Nernst lamp may not be materially shortened when burning on direct-current circuits, it is necessary to connect it in circuit so that the current shall flow through the glower in a certain direction; and in order to determine the polarity of the socket a polarity indicator accompanies each lamp. The glower is provided with three prongs arranged in an isosceles triangle, so that there is but one way of putting it in the lamp, so that mistakes in this direction are eliminated. The globe and holder are shown in Fig. 12. The illustrations show a 32-candle-power lamp, the consumption of which is in the neighborhood of 100 watts. Other features of the lamp, especially the simplicity of its construction, are shown in the engravings.

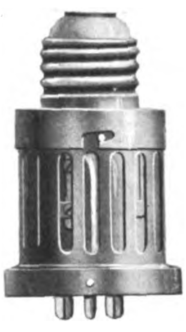
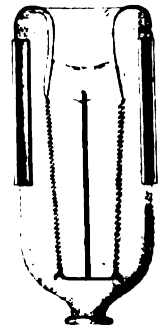



FIG. 9.—NERNST LAMP DETAILS.—FIG. 10.

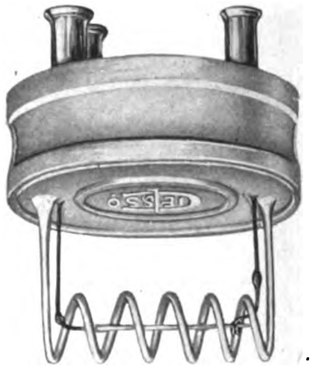


FIG. 11.—NERNST GLOWER.

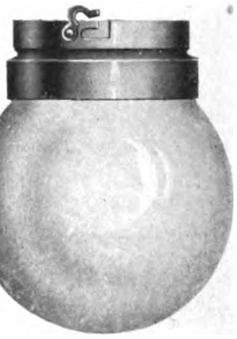


FIG. 12.—GLOBE AND HOLDER OF NERNST LAMP.

NEW ELECTRIC LIGHTING SPECIALTIES.

The Banner Electric Company, of Youngstown, Ohio, maker of the Banner incandescent lamp has lately placed some new specialties on the market. A few of these are illustrated herewith. A form of entrance plug cut-out is shown in Fig. 13. One of the advantages of this is that combinations of these blocks may be used in the

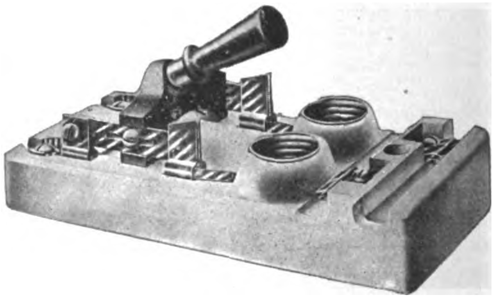


FIG. 13.—CUT-OUT.

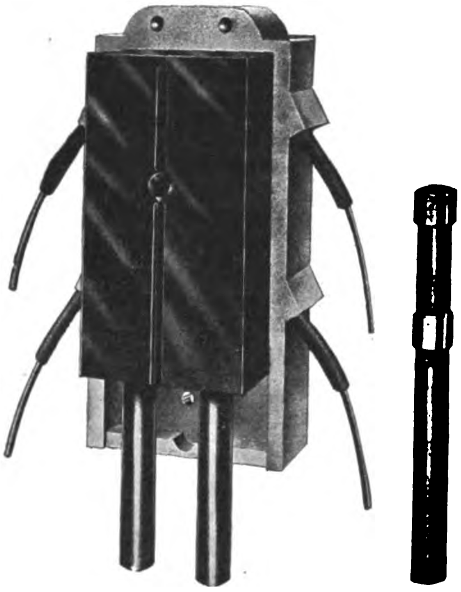


FIG. 14.—WEATHER-PROOF CUT-OUT.

place of panel or tablet boards, so that what is virtually a switchboard can be built up from these units. They can be so arranged as to take off branches from one or both sides of the mains, each branch being supplied with switchboard and fuse connections. They are made for standard fuse plugs. The base is of glazed porcelain and the copper and brass parts are highly finished. The weather-proof, double-pole fuse cut-out shown in Fig. 14 is an interesting device used principally in connection with alternating arc lamp service. The contact points cannot be reached except by means of the fuse tubes shown, so that a heavier fuse than should be used cannot be connected. In this way the lamp is protected from excessive current, and the device can, of course, be used in many other ways where some protection is needed and can be afforded by using fuses of fixed capacity. The base of this is of glazed porcelain, and the contact points are round spring clips. The fuse tubes are of heavy hard fibre, carrying copper ferules, to which the fuses are soldered, the fuse passing through the side of the tube from one ferule to another. The arrangements is said to be such that the tube cannot jar loose or drop out when inserted in the clips, and a good contact is always insured. They are designed for 250 volts and any required capacity up to 30 amperes. The positive and negative poles are separated by a thick wall of porcelain, minimizing the possibility of short-circuit. The cover is of enamelled galvanized iron bolted to the porcelain and cemented securely around the edges so as to be waterproof. The inleading wires are soldered to the spring clips. Fig. 15 shows a new form of floor box for conduit work and the type illustrated is that which has been designed for and is to be used by the new Government Bureau of Standards as its laboratory which has recently been built at Washington. The lower part of the box is of cast-iron, while the cover is of polished brass, the center field being finished in small raised diamond-shaped figures. The center plug screws in from the bottom of the plate, and when in place comes flush with the top side. A rubber gasket is used between the brass cover and the iron box body, so as to make it perfectly water-tight.

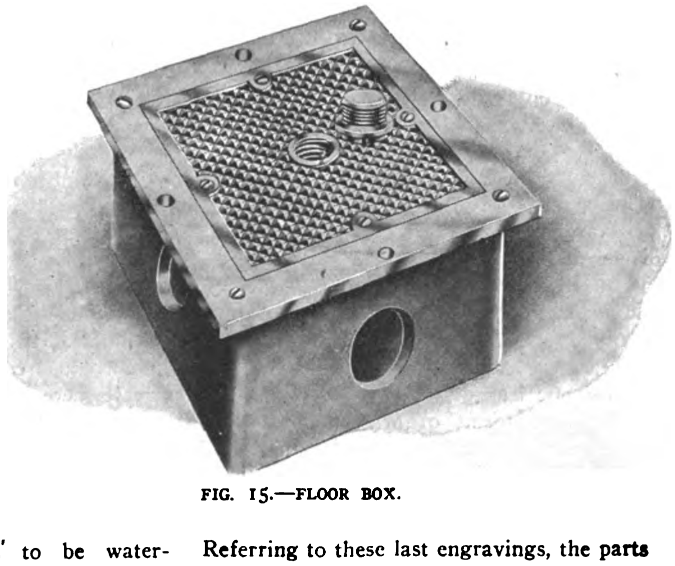


FIG. 15.—FLOOR BOX.

NEW LOCK PUSH SWITCH.

The accompanying engravings illustrate the mechanism of a new lock push switch brought out by The Hart & Hegeman Manufacturing Company, of Hartford, Conn. The complete parts of the switch are shown by Figs. 18 and 19. Fig. 16 is a plan view of a part of the mechanism but not, however, in normal position, and Fig. 17 is a view of the switch blade (bottom side up) which is superposed on the part shown by Fig. 16.

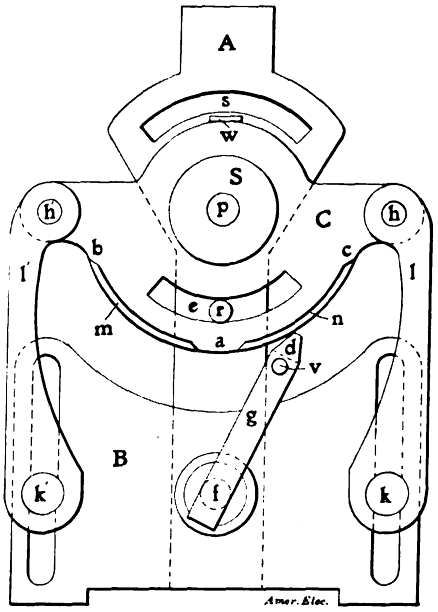


FIG. 16.—LOCK PUSH SWITCH.

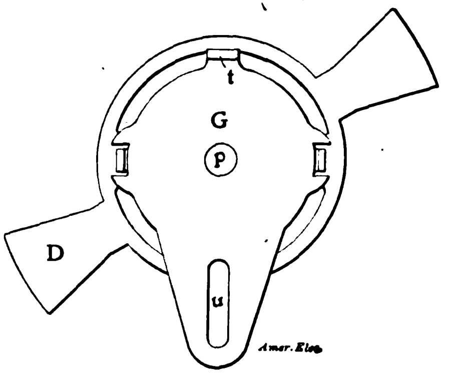


FIG. 17.—LOCK PUSH SWITCH.

Referring to these last engravings, the parts *g* and *G* form a sort of toggle joint, the pin, *v*, working in the slot, *u*. All of the parts shown in Fig. 17 are fastened rigidly together and are under the action of the spiral spring, *S*. Both ends of this spring press on either side of the fingers, *w* (projecting upward), and *t* (projecting downward) which work one inside the other, the motion of *t* being limited by the slot, *s*, and that of *w* by the stop *r* in the slot *e*. The lever, *g*, has a lip, *d* (projecting downward), at one end, which rests against the guards *m* and *n* turned up on the portion *C* and slotted at *a*, *b* and *c*. The switch operates as follows: A key pressing against the stud, *k'*, on the link, *l'*, turns the part *C* to the right. The finger, *t*, is stationary so long as the lip, *d*, is restrained from moving by the guard, *n*. The finger, *w*, moving with the part *c* puts the spring under tension, the other end of the spring being held by *t*. When, however, the part *C* has turned as far as it will go to the right, the lip, *d*, escapes the guard at *c*, passing back of it and out at *a*, then resting against the guard, *m*. As soon as the lip escapes the guard the spring is, of course, released and the blades *D*, fly over, opening or closing the circuit, as the case may be, by passing out of or into engagement with the switch jaws shown in Fig. 19. This action is almost instantaneous. The same cycle of operations is performed when the other link is pushed, the lever, *g*,

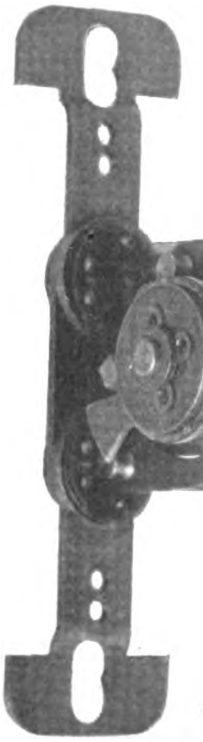


FIG. 18.—MECHANISM OF LOCK PUSH SWITCH.

then escaping from the guard, *m*, at *b*. The studs, *k* and *k'*, in their normal position are one at the bottom and the other at the top of their respective slots. The switch blades, *D*, are on one piece of brass, which is insulated from the mechanism by sheet mica. The ingenious mechanism occupies little space, and is housed in a porcelain box, which contains the switch jaws. Ample room is provided for wires. Other features of the switch are clearly indicated in the engravings.

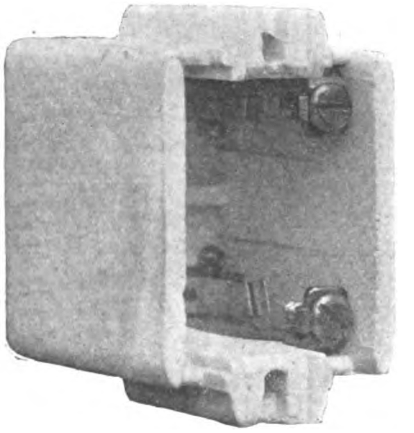


FIG. 19.—LOCK PUSH SWITCH.

A NEW ENCLOSED ARC LAMP.

Figs. 20 herewith illustrates a simple and compact form of enclosed arc lamp built by the John A. Hamblin Company, Providence, R. I. One of the chief features of the lamp is the substitution of porcelain for metal in the construction of the frame, this practice enabling the manufacturers to eliminate the numerous insulating bushings and washers necessary for the screws of a metal framework. The lamp mechanism is, of course, of the clutch type, but the clutch and dash-pot are attached directly to the magnet cores instead of being connected therewith through the medium of links or levers; this construction naturally lightens the mechanism and renders it possible to use smaller magnets than would otherwise be necessary. The magnet coils, it is stated, are wound in a specially prepared composition, which is said to make them capable of standing several times the normal current, because of the immunity from damage by overheating. The resistance wire is wound on grooved porcelain spools, the grooves being cut in the form of a screw thread. The dash-pot is provided with a graphite plunger in order to obviate sticking. The method of supporting the globe is clearly shown by the engraving; the holder is a piece of sheet metal with a hole in the center of proper size to receive the lower end of the globe and suspended from the framework by two wires, the whole constituting a sort of bail which may be readily swung to one side after the globe is lifted out of the holder. The lamp is 22 inches long over all, and weighs 11 pounds complete.

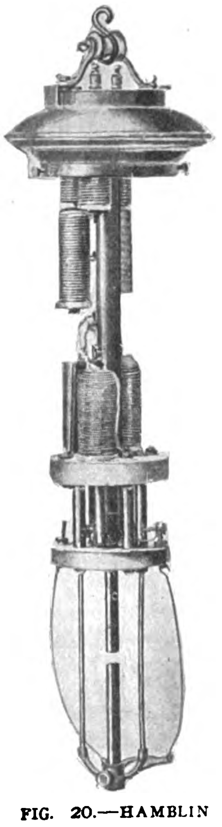


FIG. 20.—HAMBLIN LAMP.

NEW BOOKS.

ELECTRICAL INFLUENCE MACHINES; THEIR HISTORICAL DEVELOPMENT AND MODERN FORMS, WITH INSTRUCTIONS FOR MAKING THEM. By John Gray, B. Sc. (Second Edition, revised and enlarged.) New York: D. Van Nostrand Company, 1903. 296 pages, 105 illustrations. Price, $2.00.

We are glad to see a second edition of this excellent little book, the first edition of which appeared thirteen years ago. The subject of static electricity has not received a great deal of attention of late years, in so far at least as the literature is concerned; and when books on this subject are published they are not usually very satisfactory. The present volume is a happy exception; the descriptions of apparatus are full and accurate and, what is still better, theoretical questions are treated in a lucid manner.. Usually the explanations of the operation of the Holtz or Wimshurst machines, for example, are far from clear, leaving the reader in no better position than he was before. There is, however, nothing so abstruse about the theory as to account for this; it is rather due to the fact that good writers have not heretofore given much attention to the subject. We can recommend this book to all who are interested in static electricity.

CONTINUOUS-CURRENT DYNAMOS AND MOTORS. By W. R. Kelsey. New York: D. Van Nostrand Company; London: The Technical Publishing Company, Limited. Cloth; 440 + viii pages, 5 x 7 ins.; 225 illustrations; 14 tables. Price, $2.50.

This book is of the usual character of text-books on the principles of dynamo and motor construction, containing an exposition of these principles and a more or less authoritative discussion of the more important features of design and construction. It has the merits of clear diction and absence of pedantry, and has been brought right up to date in the matter of methods of design and construction with the exception that the author wastes much time and space on an academic discussion of the calculation of magnetic leakage, and has omitted several modern forms of brush-holders that are practically standard. The treatment of commutation is elaborate and interesting, but neither practical nor conclusive. The book unfortunately abounds with typographical errors, one of the most serious, and one which escaped notice, being the use of *N* instead of *T* throughout page 219, except on the last line, where either *N* or *T* would be correct.

STORAGE BATTERY ENGINEERING.—A Practical Treatise for Engineers by Lamar Lyddon. New York: McGraw Publishing Company. Cloth. 382 pages, 6 ins. x 9 ins.; 177 illustrations and diagrams. Price, $3.00.

The author starts out with the statement that the lead-lead cell being in general use, practically to the exclusion of all other types, it alone will be considered in detail in the book. Considering the intended scope of the book as indicated in the title, this is a wise plan. Storage battery engineering usually means lead-lead battery engineering. The first chapter treats of "General Theory," the refinements of theoretical speculation being left out. This also is commendable, for although much theoretical investigation of high value has been made, there is a larger amount of worthless material to be found in the current storage battery literature, and it is better to leave this material out altogether than to make extracts from it, unless the editorial blue pencil is used more freely and with more judgment than by most of the compilers of storage battery books. In the chapter on "The Electrolyte" are given directions for making qualitative chemical tests for all the impurities that are of any importance from an engineering point of view, and the usual table of specific gravities and percentages of sulphuric acid of different strengths. Further on the different modifications of the Planté formation and the Faure system are discussed somewhat fully.

The second part of the book, comprising nearly one-half, is devoted to "Auxiliary Apparatus, Systems, Applications." The relative importance of this branch of the subject, from the point of view of the storage battery engineer, is about commensurate with the space here devoted to it. Without boosters, regulating devices, etc., storage batteries would be impracticable in many situations.

The plan of this book is to deal more particularly with general principles and not to any extent with particular makes of cells. For example, in the chapter on "Testing" will be found directions for determining the different quantities relating to the performance of a cell, such as capacity per pound of complete cell, or of element, but if the reader looks for information on this or any similar point in regard to existing cells, even of the best known types, he will be disappointed.

There is a statement on page 30 to the effect that watt-hours may be obtained by multiplying the average voltage by the ampere-hours. This is strictly true only when the current is constant for the whole time. In case there are no very great fluctuations in the current it may be approximately true, especially when the voltage falls off gradually and uniformly.

As already indicated, the plan of this book is different from that of other books treating of storage batteries, so it is not a mere duplication of other works. It is, on the whole, a very creditable work and a valuable addition to storage battery literature.

OBITUARY.

JOHN C. DANIELS, president of the Garton-Daniels Company, died recently at his former home, Eauclaire, Wis., whither he had gone in the hope of building up his impaired health. Mr. Daniels was sixty-three years old at the time of his death.

PERSONAL.

MR. RALPH D. MERSHON, the well-known consulting engineer, has just returned from a trip to Europe.

MR. A. E. BAKER has been appointed district sales agent at the Philadelphia office of the Nernst Lamp Company to succeed Mr. J. M. Martin, resigned.

MR. CHARLES T. BISHOP, formerly a paymaster in the United States Navy, has been appointed auditor of the H. W. Johns-Manville Company, New York.

MR. D. A. SCHUTT, who has been superintendent of the Peru Electric Manufacturing Company, Peru, Ind., for the past twelve years, has resigned that position, his resignation to take effect January 1.

MR. JOHN MAHONEY, who has had nearly thirty years of practical experience in street railway work, has been appointed general superintendent of the St. Louis Suburban Railway Company, St. Louis, Mo.

MR. J. J. BELLMAN has been elected vice-president of the Indestructible Roadbed Company, which controls the franchises and charter of the Sandusky, Monroeville, Belleville & Norwalk Traction Company.

PROF. W. ELWELL GOLDSBOROUGH will deliver an address before the Chicago Branch of the American Institute of Electrical Engineers on December 8, the subject being "The Electrical Features of the Coming Louisiana Purchase Exposition."

MR. ALEXANDER HENDERSON, who served as master of transportation for the recent convention of the National Electrical Contractors' Association, was presented on November 5 with a handsome loving cup by members of the Association as a mark of their esteem and appreciation of the work he has done for that organization.

MR. JACOB CLOOS, formerly technical manager of the Milwaukee Edison Illuminating Company, has been appointed manager of the Milwaukee office of the Downward Light Electric Company, New York, manufacturer of the "Downward Light" tipless incandescent lamp recently described in this paper.

MR. J. D. HOGE, secretary of the Federal Telephone Company, Cleveland, has been made general manager of all of the properties of the Federal Company, to succeed Mr. Maxime Reber. Mr. C. Y. McVey, at present manager at Youngstown, will be assistant general manager of the Federal Company.

MR. IRVING H. REYNOLDS, chief engineer of the Allis-Chalmers Company, will shortly retire from this position, and the duties of chief engineer will be divided up between the engineers in charge of the various departments, who will have the advantage of advice from Mr. Edwin Reynolds, consulting engineer of the company and for many years its chief engineer and superintendent.

MR. MORTIMER J. HIGLEY, recently resigned his position as superintendent of the Belvidere Gas & Electric Company, as noted in this column last month, but the statement that Mr. Higley is connected with the Iowa City Gas Light Company was erroneous. He has accepted the position of private secretary to a retired capitalist in Iowa City and has no connection whatever with the Iowa City Gas Light Company.

MR. JOHN CALDER, for sometime past executive engineer of the C. W. Hunt Company, recently resigned his position there to accept the managership of the Remington typewriter factory at Ilion, N. Y. Mr. Calder left the Hunt works on Saturday, November 14, and just before leaving he was treated to a very pleasant surprise in the shape of the presentation of a handsome silver loving cup from the employees of the company.

MR. FRANK MARTIN, who for several years has been in charge of the electrical department of yards and docks at the Brooklyn Navy Yard, has resigned in order to take charge of the electrical department of the University Power Company, Princeton, N. J., which has just installed a large plant for supplying light, heat and power to the citizens of Princeton; the company's customers include the University. Prior to his work at the Navy Yard, Mr. Martin was connected with the Edison Electric Illuminating Company, of New York.

TRADE PUBLICATIONS.

SMALL DIRECT-CURRENT MOTORS. Northern Electrical Manufacturing Company, Madison, Wis.—Booklet No. 33, devoted to a new line of direct-current motors ranging from 1/8 to 3 horse-power in output.

ELECTRICAL SUPPLY PRICE LIST. Central Electric Company, Chicago.—This price list is supplementary to the Central Electric Company's general 1903 catalogue and is very conveniently arranged and attractively executed.

WATER WHEEL GOVERNORS. Woodward Governor Company, Rockford, Ill.—A handsomely executed catalogue of standard size, containing well illustrated descriptions of the several types of Woodward water wheel governor.

MILLING MACHINES AND MILLING CUTTERS. The Hess Machine Company, Philadelphia, Pa.—A well executed catalogue of standard size, devoted exclusively to planer type milling machines using slabbing cutters for fast feeding.

STEEL PLATE FANS. American Blower Company, Detroit, Mich.—Catalogue No. 155, devoted to the line of A. B. C. steel plate fans for heating, ventilating and drying plants, forced and induced draft apparatus, etc.

COAL WASHING MACHINERY. The Jeffrey Manufacturing Company, Columbus, Ohio.—Catalogue No. 52, containing illustrated descriptions of this class of machinery and also illustrations of representative equipments of Jeffrey apparatus.

ELECTRICAL DATA. Chase-Shawmut Company, Newburyport, Mass.—This is the 1904 edition of this well-known publication. The present edition is considerably thicker than previous issues and contains many very useful diagrams and tables.

HEWITT MERCURY VAPOR LAMPS. Cooper Hewitt Electric Company, New York.—A catalogue of standard size, devoted to the Cooper Hewitt mercury vapor lamp and containing illustrations of interiors illuminated by means of these lamps, together with diagrams of connections.

DIRECT-CONNECTED GENERATORS. Fort Wayne Electric Works, Fort Wayne, Ind.—This is bulletin No. 1050, superseding bulletin No. 1024 and containing an illustrated description of the standard Wood direct-connected direct-current generator.

ELECTRICAL NOVELTIES AND SPECIALTIES. Electric Contract Company, New York.—Catalogue No. 4, containing illustrations and price lists of a large number of electrical specialties. The line includes electric scarf pins, gas lighters, portable lanterns, medical sets, test batteries, dry batteries, spark coils, etc.

MECHANICAL DRAFT APPARATUS. American Blower Company, Detroit, Mich.—This is the second edition of catalogue No. 118 and contains an interesting discussion of mechanical draft, together with numerous illustrations of the various pieces of apparatus required for complete equipment and different methods of applying it.

INCANDESCENT LAMPS. Sawyer-Man Electric Company, New York.—Folder No. 4014, containing a discussion of the initial selection of lamps, economy of frequent renewals and the value of voltage regulation, together with descriptions of the Sawyer-Man line of lamps and the usual tabulated data.

BANNER SPECIALTIES. The Banner Electric Company, Youngstown, Ohio.—A pocket size booklet, containing illustrations and brief descriptions of these specialties, which include combined entrance switches and fuse cut-outs, weather-proof double-pole fuse cut-outs, conduit floor boxes and automatic time switches.

MOTOR STARTERS. The F. Bissell Company, Toledo, Ohio.—Bulletin No. 26, forming a part of the Bissell Company's perpetual catalogue and devoted to motor starting boxes of all standard types, including the multiple switch form, reversing rheostat form, automatic organ motor regulators, drum controllers for crane and hoisting motors, and the well-known Cutler-Hammer solenoid controller for elevator motors.

GAS vs. ELECTRICITY. Wagner Electric Manufacturing Company, St. Louis, Mo.—A very interesting bit of industrial history attractively presented in pamphlet form, and consisting of an account of the struggles between the gas company and the electric light company of a central-west city of about 100,000 inhabitants. The story is well worth the attention of central station managers.

MECHANICAL DRAFT. Buffalo Forge Company, Buffalo, N. Y.—This is a very handsome catalogue, bound in cloth, and containing illustrated descriptions of all of the very complete lines of mechanical draft apparatus built by the Buffalo Forge Company. The book contains in addition to the simple descriptive material a large amount of useful information concerning mechanical draft and the apparatus incident to the application thereof.

WIRE ROPE. American Steel & Wire Company, Chicago and New York.—A well-executed catalogue, containing illustrations, price lists and complete tabulated data relating to the various classes of wire rope manufactured by the American Company. These include crucible cast-steel hoisting ropes and transmission ropes; plow-steel, monitor-steel and galvanized iron and steel ropes, hawsers, tiller ropes and suspension bridge cables. The catalogue also contains useful instructions for splicing wire rope and some remarks on the transmission of power for such ropes.

WIRE ROPE. Hazard Manufacturing Company, Wilkesbarre, Pa.—A very complete catalogue of convenient size, relating to the line of wire ropes manufactured by this company. This line includes Swedes iron elevator ropes, Lang lay ropes made of cast-steel or plow-steel, and Hazard plow-steel wire ropes. The catalogue also covers galvanized mast arm rope, steel hawsers, bridge cables and locomotive switching and wrecking ropes. It contains further a very useful diagram showing the proper working load for wire hoisting ropes corresponding to different diameters of drums, and some extremely useful remarks concerning the use and care of wire ropes.

BUSINESS NEWS.

BROWN CORLISS ENGINE COMPANY, Corliss, Wis., has made arrangements to handle a line of foreign-built gas engines for operation on blast furnace gas.

CROCKER-WHEELER COMPANY, Ampere, N. J., has established a Southern office at Atlanta, Ga., in the Empire Building, in charge of S. M. Conant.

THE ELECTRIC APPLIANCE COMPANY, Chicago, is sending out samples of its "O. K." duplex telephone wire, for which strong claims are made. The insulation is made in three colors; brown, maroon and black.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, has established a branch office at 24 Boulevard Voltaire, Paris, France, where a complete line of Lunkenheimer specialties will be carried in stock.

BALL ENGINE COMPANY, Erie, Pa., has just moved into its new works which were erected during the past year as a result of such a growth in business as to make the old works entirely inadequate to the company's needs.

THE WAGNER-PALMROS MANUFACTURING COMPANY, manufacturer of coal-handling machinery of all kinds, has opened offices in the House Building, Pittsburg, Pa., which are in charge of Eduard Schenk, the well-known civil engineer.

MODEL STOKER COMPANY is the name of a new concern organized by Mr. O. D. Cotton, the well-known mechanical stoker expert, who was for many years connected with the Murphy Iron Works. The new company will build and market a new automatic furnace invented by Mr. Cotton.

CENTURY ELECTRIC COMPANY is the name now of the well-known concern which has heretofore done business under the style of H. E. Lindsey Electrical Supply Company. The company remains at the old headquarters, 1007-1011 Locust Street, St. Louis, Mo.

AMERICAN ELECTRICAL HEATER COMPANY, Detroit, Mich., manufacturer of electric heating appliances reports that its business is the largest in its history, and for 1903 has shown an increase of over 50% over any preceding year. The company has ample facilities in its new factory for making prompt shipments.

AMERICAN REFLECTOR & LIGHTING COMPANY, Chicago, has been compelled by growth of business to remove from its old quarters to 199-205 Van Buren Street, where very much more floor space is available. The new quarters have been equipped with all modern facilities for the company's line of work.

ECK DYNAMO & MOTOR WORKS, Belleville, N. J., reports that its business is much better now than for some time previously, especially in motors of the larger sizes built by the works. Machines of all sizes up to 10 horse-power are kept in stock ready for shipment, and the Works build motors now up to 20 horse-power.

THE REYNOLDS ELECTRIC FLASHER MFG. COMPANY, Chicago, has had the usual fall rush to secure sign flashers before the holiday season, and the demand this year has been heavier than ever before. Shop facilities have been so much taxed to keep up with orders that floor space has been materially increased and the company now hopes with its increased facilities to be able to fill orders more promptly.

THE PELTON WATER-WHEEL COMPANY. San Francisco, has in hand a large amount of heavy water-wheel work for plants along the Pacific coast, from British Columbia down to the Mexico border. Among recent contracts are two 1800-kw. units for the Seattle municipal plant; three 1500-kw. units for the Vancouver Power Company, and a large number of smaller units ranging from 400 to 800 horse-power.

W. T. PRINGLE, Philadelphia, the well-known manufacturer of switchboards, switches and other specialties, has removed from 114 North 12th St. to 1906 North 6th St. in order to secure the larger quarters and better facilities which his rapidly growing business demanded. Mr. Pringle's new factory is about five times the size of his old one, so that he is now in position to turn out orders without delay and with comfort.

THE GOULD STORAGE BATTERY COMPANY, New York, reports brisk business in its line of work. Among the contracts recently secured are two from the N. Y., N. H. & H. R. R. Company and the Narragansett Electric Lighting Company, Providence, R. I. The equipment for the New Haven road comprises two batteries of 55 cells each to be used for lighting service at the company's Bristol and New Britain stations. The contract with the Providence company is for an equipment of positive plates to have an aggregate capacity of 320,000 ampere-hours and to take the place of plates in a battery of another make.

THE LAGONDA MFG. COMPANY, Springfield, Ohio, recently received the following letter, which speaks for itself:

"Our superintendent and engineers are all delighted with the reseating machine. They can clean all the headers, caps and nuts of our 400-h.p. water-tube boiler in about two hours. It is a great saving of time and improvement over the old way of cleaning. The important part is that when you put back the caps, you have a perfect joint and not a leaky cap.

(Signed) The Ansted & Burk Company.,
J. W. Burk, Mgr."

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, recently closed a contract with the Indiana Interurban Construction Company for the installation of a battery of "Chloride" accumulators for the Kokomo, Marion & Western Traction Company, at Kokomo, Ind. This battery will consist of 288 cells having a capacity of 384 kilowatts, to be used in regulating the load on 60-cycle rotaries so that the lighting and railway service can be obtained from the same generators. A contract has also been closed with the U. S. Department of Commerce and Labor, Washington, D. C., for two batteries to be operated by the National Bureau of Standards at Washington; and one with the Bacon Air Lift Company for the residence of Hermon B. Duryea, Westbury, L. I. This latter installation consists of a battery of 68 cells, having a capacity of 46 kilowatts to be used for lighting and power after the generator plant is shut down for the night.

A NOVEL USE FOR A REFRIGERATION MACHINE.—In some electrical tests, where exact results are required, it is important that certain instruments, or baths, or chambers, be maintained at a constant temperature, and in other tests it is quite necessary that the air be comparatively dry. To secure these desirable conditions in its new laboratories at 80th Street and East End Avenue, New York, the Lamp Testing Bureau has installed a refrigerating machine which will cool the air of one room to the temperature required and extract moisture from the air of another room when the humidity is higher than it should be for the best working conditions. The Bureau hopes to have its new laboratories ready for work about January 1, 1904, when it will abandon its present temporary quarters at 14 Jay Street. The equipment of the new laboratories is planned to be as complete and up to date as it can be made. Nothing better indicates the broad policy of the company than the fact of its having recently sent its test officer, Dr. Clayton H. Sharp, to inspect all of the principal electrical laboratories of Europe, so that on his return he may be better able to equip the new laboratories to meet the needs of those who may require its services. During Dr. Sharp's absence, the company has secured the services of Dr. C. P. Matthews, late of Purdue University, to advise concerning the photometric equipment of the new laboratories.

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GENERAL INDEX

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1 to 72 in January; 73 to 112 in February; 113 to 170 in March; 171 to 210 in April; 211 to 250 in May; 251 to 328 in June; 329 to 386 in July; 387 to 434 in August; 435 to 474 in September; 475 to 528 in October; 529 to 574 in November; 575 to 620 in December.

**References to Notes in "Abstracts from Foreign Contemporaries" are distinguished by an asterisk preceding the page number.*
Descriptions of telephone exchanges are indexed only under the head, "Telephone."
Descriptions of central station plants are indexed only under the head "Central Station" and the names of the cities.

A

Air, Compressed, as a cleaner (Edit.) 93
Air-compressors for railway brakes; General Electric Co. 323
——— ———, Portable motor-driven; John Stevenson Co. 381
Allentown Rolling Mills: Aldrich horizontal quintuple pump 382
Allis-Chalmers Company's annual report 384; New gas engine 379
Alphaduct Mfg. Co.: Fire-proof fibre conduit 110
Alternating-current circuits, Measurement of power in, By N. R. Craighill 460
——— ——— ——— ——— ——— with three voltmeters 606
——— ——— composite circuits for distribution and transmission of electrical energy, By A. S. M'Allister 175
——— ——— operation, A problem in, See Problem ....
Alternator regulation, By B. C. Wilson..... 158
Alternators, Parallel operation of, By W. T. Fernandez, 155; *223; F. Hardie Jeannin 517
——— in parallel, Single-phase, 60-cycle, By Junior Parrish 321
———, S. K. C. revolving-field; Stanley Elec. Mfg. Co. 107
——— The governing of, ... *141
——— Wrought-iron armature frames for... *43
Alumino-thermics 591
Aluminum, Electrodeposition of, from aqueous solutions, By Frank A. McDermott and Joseph W. Richards 565
American Conduit Co.: Bituminized fibre conduit 325
American Railway Mechanical and Electrical Association organized, 145, (Edit.).. 147
Ammeter, Long scale alternating current; Westinghouse Elec. & Mfg. Co. 245
Anderson-McCutchen Co.: Feed-water heater. 472
Arc, The electric, (Lessons) 100
Arc lamp, An interchangeable; Osborn-Morgan Co. 206
——— ——— carbon, Blondel, (patent) ... 43
——— ——— construction, By Roy C. Jackson 565
——— ———, Construction of a direct-current enclosed; 510
——— ———, Enclosed; General Incandescent Arc Light Co. 326
——— ——— ———; Jno. A. Hamblin Co. .. 620
——— ———, Fish, (patent) 549
——— ———, Fish multiple, (patent) 360
——— ——— operation, Some points in, By Daniel B. McBride 428
——— ——— regulating mechanisms (Lessons) 157
Arc lamps, Application of 4-ampere series alternating enclosed, to city lighting, By J. Henry Hallberg 369
——— ———, Series operation of, by rectified currents *306
——— ——— with impregnated carbons *184
Arc lighting systems, Operation of, ... *356
Armature core loss, Test for, (Q. & A.) 468
——— frames, Wrought-iron, for large alternators *43
——— windings, Balcome drum, (patent) 144
——— ———, Laying out, (Edit.) 93
Armatures, Centrifugal force in, (Edit.) 552
Atmospheric electricity, Mr. Cerny's expereince with, By T. N. Slocum 376
Atomizer, Oil. See Oil atomizer.
Atwater-Kent Mfg. Co.: Monoplex intercommunicating telephone system 111
Automatic Electric Co.: Automatic telephone system 161
Automatic Electric Pump Co.: New automatic electric pump 249
Automatic Time Stamp Co.: Time stamp for telephone switchboards 246
Automobile, Design for an electric runabout, By J. C. Brocksmith 48
——— storage battery data *87

B

Ball Engine Co.: New engine governor 70
Banner Elec. Co.: Fuse cut-outs 618
Barron, J. S. & Co.: Cable clip 248
Bartlett, C. O., & Snow Co.: Fuel feeder and regulator 71
Bates Mch. Co.: Numbering machine 618
Battery, Dry, tests; Wm. A. Roche 112
———, Primary, Electrotonic; Swan Electric Mfg. Co. 111
———, Storage, charging temperature 471
——— ——— connections, Testing the polarity of, without a polarized voltmeter, By W. S. Bury 520
——— ——— Data of automobile, ... *87
——— ——— cells, New, ... *548
——— ——— operation, Practical, By H. P. Liversidge 462
——— ———, Smith, installation in Hotel Carlton, Boston 327
——— ——— Test of the Clare, ... 68
Bell connections, Problem in. See Problem.
Belt action on pulleys out of line, By C. N. Rutherford, 203; Elmer E. Warner 240
Berkshire Street Railway Co., High-tension alternating current installation of, ... 387
Binding posts and common sense terminals, By Elmer E. Warner 315
Bissell, F. Co.: Linemen's cable car 474
Boiler accessories, By Chas. L. Hubbard 194
——— blow-off, The, By W. T. Edwards ... 425
——— cleaner, Garrigus mechanical; Mechanical Boiler Cleaner Co. 169
——— ———; General Specialty Co. 471
——— compound and oil feeders, By Jas. F. Hobart 95
——— and furnace efficiencies, By A. Bement 351
——— practice in electric light and power stations, Some points regarding, By Geo. H. Barrus 256
———; Robb-Mumford Boiler Co. 247
——— settings, By Chas. L. Hubbard 557
———, The Sudgen water tube *88

Books, New:

The Alternating-Current Transformer, By F. G. Baum 574
The American Steel Worker, By E. R. Markham 525
The Art of Illumination, By Louis Bell. March Adv. 62
Civil Engineer's Pocket Book, By John C. Trautwine ....Feb. Adv. 58
Conductors for Electrical Distribution, By F. A. C. Perrine 328
Continuous-Current Dynamos. By W. R. Kelsey 620
Design of Dynamos, By Silvanus P. Thompson ....Feb. Adv. 57
Dies: Their Construction and Use for Working Sheet Metals, By Joseph V. Woodworth 328
Electric and Magnetic Calculations, By A. Atkinson 384
Electric and Magnetic Circuits, By Ellis H. Crapper 433
Electrical Engineering Measuring Instruments, By G. D. Aspinwall Parr, Sept. Adv. 51
Electrical Engineer's Pocket Book. (Third edition.) By Horatio A. Foster Feb. Adv. 58
Electric and Magnetic Calculations, By A. A.
Electrical Influence Machines. By John Gray 620
Electrical Problems, By Wm. L. Hooper.. 209
The Electrician Electrical Trades Directory, London, The Electrician Printing & Publishing Co. 328
Elements of Electrical Engineering, By Tyson Sewell ....March Adv., 62, 250
Handy Electrical Dictionary, By W. L. Weber ....Feb. Adv. 58
Hardening, Tempering, Annealing and Forging Steel, By Joseph V. Woodworth 433
The How and Why of Electricity, By Charles Tripler Child 384
Mechanical Engineer's Pocket Book (1903 edition), By Wm. Kent 210
Proceedings of the National Electric Light Association. Twenty-fifth Convention ... Feb. Adv. 57
The Slide Rule, By Chas. N. Pickworth 574
Storage Battery Engineering. By Lamar Lyndon 620
Students' Guide to Submarine Cable Testing, By H. K. C. Fisher and J. C. H. Darby 525

Booster, Reversible, ... *357
———, A simple alternating-current, By F. B. O'Hanlon 481
———, Direct-current, Erben & Knight, (patent) 44
Bracket frame, Cable; C. M. Gest 432
Brake, Design for a 15-horse-power dynamometer, By N. R. Craighill 190
———, A simple prony, ... 420
Brakes, Prony, for motor testing 84
British Westinghouse Co.: A large commutator 430
Bronx Gas & Electric Company's central station at Westchester, N. Y. 529
Brush-holder, Eck, (patent) 550
Bryan-Marsh Co.: New incandescent lamp... 474
Burger gas engine; Woolley Fdry. & Mch. Wks. 569
Burner, oil, ... 593
Butler Chuck Co.: Drill chuck 72

C

Cable bracket frame; C. M. Gest 432
——— clip; J. S. Barron & Co. 248
Cable jointing device; Cable Joint and Electric Appliance Co. 472
——— painter, "Larsen" 109
———, submarine, Making and laying a 500-mile, ... 66
Calculator for testing wattmeters; Queen & Co. 383
Camp Co., H. B.: Split tile conduit 617
Canals, Electric haulage on French, By Geo. E. Walsh 266
Canals, Electric traction on American, ... 584
Capacity of transmission lines (Edit.)........ 454
Car, Linemen's cable; F. Bissell Co. 474
Carbon, Arc lamp, Blondel, (patent) 43
Catechism, Electrical, ...64, 103, 159, 203, 241
Cement for marble 220
Census report of United States light and power plants 453
Central Railroad of N. J. shops at Elizabethport, N. J., Electrical Equipment of,.. 435
Central station, An oil engine, By Howard S. Knowlton 494
——— ——— of the Bronx Gas & Electric Company at Westchester, N. Y. 529
——— ——— of the DeKalb-Sycamore Electric Co., By J. R. Cravath 251
——— ——— of the Meriden Electric Light Company 575
——— ——— records and returns *449
——— ——— service *vs.* isolated plants (Edit.) 311
——— ———, Swiss (Galdach-St. Gall) combined water-power and gas-engine, ... 113
Central stations, Breakdown precautions in, (Edit.) 414
——— ———, Causes of trouble in, ... 255
——— ———, City pumping from, 231 (Edit.) 232
——— ———, Coal supply for, (Edit.) 415
——— ———, Progressiveness of small, (Edit.) 310
——— ———, United States census report of, 453
Centrifugal force in fly-wheels (Edit.) 552
Chimney, circular, Wind pressure on, (Q. & A.) 204
Chuck, Drill; Butler Chuck Co. 72
Circuit-breaker, The, (Lessons) 426
——— ———, Oil, for high-tension circuits; Westinghouse 169
——— ——— for polyphase motors; Cutter Company 249
——— ———, A simple form of, By S. M. Kintner 234
——— ———, S. K. C.; Stanley Elec. Mfg. Co. 324
Circuits, Composite, for the transmission and distribution of electrical energy, By A. S. M'Allister 175
———, alternating-current, Measurement of power in, By N. R. Craighill 460
Clark, Thos. E., Wireless Tel-Tel. Co.: Wireless telegraph outfit 383
Climber, Linemen's; Smith & Hemenway Co. 169
Coal supply for central stations (Edit.).... 415
Coherer, A simple, By F. W. Cerny 62
Commutator construction, Improved, By Walter Brown 428
———, A large; British Westinghouse Co. .. 430

Compensator, Voltmeter; Stanley Eectric Mfg. Co. 430
Condenser, Richmond's surface, *185
Condensers, Improved jointing arrangement for tubular surface, *184
——, Improvements in surface, *185
—— for steam turbines *87
Conductivity of hard drawn copper wire (Q. & A.) 322
Conduit, Bituminized fibre; American Conduit Co. 325
—— fastener; Hart & Hegeman Mfg. Co. 206
——, Fire-proof fibre; Alphaduct Mfg. Co. 110
——, Split tile; H. B. Camp Co. 617
Congress, International Electrical, 309, (Edit.) 415
Consolidated Engine Stop Co.: Monarch motor stop 326
Control, Automatic car, *450
——, Relative advantage of electrical and mechanical methods of variable speed, for general power service, By Wm. Cooper, 337, (Edit.) 362
—— system for the New York subway motors 205
Controller, Electro-mechanical; Lombard Governor Co. 109
——, Multispeed motor; Cutler, (patent) 595

Conventions:

American Electrochemical Society 227, 503
American Institute of Electrical Engineers 398; (Edit.) 414
American Society of Mechanical Engineers 361
American Street Railway Association 497
Association of Edison Illuminating Companies 505
Canadian Electrical Association 361
Engine Builders' Association 45
Independent Telephone Association 358
International Association of Municipal Electricians 496
Interstate Independent Telephone Association 45
National Electrical Contractors' Association 413
National Electric Light Association 341
New York State Independent Telephone Association 360
Northwestern Electrical Association 89

Converse high-tension insulator (patent) 452
Converter, Current, Peter Cooper Hewitt, 81
Converters, rotary, Hunting of, By Clarence P. Fowler 556
—— ——, Operation of, By W. T. Fernandez 458
—— —— *vs.* motor-generators (Edit.) 552
Conveyors, Newspaper; Link-Belt Engineering Co. 166
Couch & Seeley Co.: Iron box telephone 524
Crane, floor, Convenient repair shop, By Francis H. Doane 364
Crouse-Hinds Electric Co.: Permanent conduit and sign receptacle, 72; Porcelain electric specialties 112
Current densities in standard wires 526
——, New method of obtaining constant, By F. Hardie Jeannin 412
Currents, Relation between effective and mean values of, By J. J. Cort 370
Curtis steam turbine; General Electric Co. 244
Curves, Determination of induction, motor characteristic, By A. S. M'Allister 15
Cutler-Hammer Mfg. Co.: New field rheostat 572
Cut-out, Railway section, 43
—— —— and snap switch combined; Hart & Hegeman Mfg. Co. 523
Cut-outs, Fuse; Banner Elec. Co. 618
Cutter Company: Circuit-breaker for polyphase motors 249

D

De Kalb-Sycamore Electric Co.'s central station, By J. R. Cravath 251
De Laval Steam Turbine Co.: Direct-current turbine-dynamos 165
De La Vergne Refrigerating Machine Co.: Hornsby-Akroyd oil engine 326

Designs for Apparatus:

Ammeter or voltmeter, Magnetic vane, By J. C. Brocksmith 600
Arc lamp, Construction of a direct-current, 510
Brake, 15-horse-power dynamometer, By N. R. Craighill 190
Circuit-breaker, A simple form of, By S. M. Kintner 234
Crane, Repair shop floor, By Francis H. Doane 364
D'Arsonval mirror galvanometer, By F. W. Cerny 94
Dynamo, Design for a 150-ampere electroplating, By Cecil P. Poole 312
Motors, Self-starting single-phase induction, ½-h.p., 148; 1-h.p., 416; 2-h.p., 456
Runabout, An electric, By J. C. Brocksmith 48
Transformer, Small variable voltage, By W. B. Roberts 554

De Veau automatic intercommunicating telephone system, By A. Dallam O'Brien 316
Downward Light Electric Co.: Incandescent lamp 572
Draft, Mechanical, By Chas. L. Hubbard 215
Drafting Instrument, Improved; Universal Drafting Machine Co. 69
Dryer, A new vacuum *143
Duncan Electric Mfg. Co.: Integrating wattmeters for direct current 167
Duster, Kraushaar's universal; P. Peiffer 326
Dynamo, Design for 150-ampere electroplating, By Cecil P. Poole 312
——, Midget; Elbridge Elec. Mfg. Co. 245
—— and motor troubles *502
——, series-wound, Action of a shunt-wound motor when driven by a, By A. S. M'Allister 79
——, Unusual performance of a, By H. B. Charles 101
Dynamos, Direct-current turbine; De Laval Steam Turbine Co. 165
——, Failure of direct current, to generate, By E. C. Parham 238
—— and motors, Conical pole-pieces for, *408
——, Parallel operation of steam and water driven, (Edit.) 363
——, Some hints on the care and paralleling of direct-current, By Ralph Scott 193
Dynamometer, Formula for obtaining the constant of a Siemens, 104

E

Easton & Co., Ltd.: Remarkable steam engine performance 178
Eck brush-holder (patent) 550
Efficiencies, Boiler and furnace, By A. Bement 351
Efficiency of a motor, Formula for commercial, (Q. & A.) 160
Elbridge Electrical Mfg. Co.: Midget dynamo 245
Electricity from ether, 506; (Edit.) 509
Electrochemical question, An, By W. A. Sherlock 103
Electrolytic apparatus *451
—— recovery of tin from scrap *88
Electromagnet construction (Edit.) 553
——, A powerful, *546
Electroplating dynamo, Design for 150-ampere, By C. P. Poole 312
Elevator, Electric, mechanism *501
Elevators, Electric control for, By H. D. James 83
——, —— vs. hydraulic, (Edit.) 599
——, Induction motors for, By A. B. Weeks 318
Engberg Electric & Mechanical Works: Electrohydraulic valve 431
Engine, Gas. See also Gas engine.
—— ——; Allis-Chalmers Company 379
—— ——; Burger automatic; Woolley Fdry. & Mach. Wks. 569
—— ——; Ruger Mfg. Co. 522
—— ——, Walrath; Marinette Iron Works Mfg. Co. 110
—— ——; Westinghouse Mch. Works 163
——, Gasoline; Lowell Model Co. 250
—— oil, Hornsby-Akroyd; De La Vergne Refrigerating Machine Co. 326
—— —— Nicholson, *409
—— —— Secor standard; General Power Co. 207
——, steam, Francke four-ported, 168
—— ——, Remarkable performance of English, 178
—— ——, Tests of a Belgian, using superheated steam, 217; (Edit.) 233
—— ——, Warren rotary; Rotary Engine Co. 570
Engines, heat; Thermal efficiency of, 597
Engines, steam, American, for electric light and power service, By H. F. Schmidt 267
—— ——, for electric power stations, By George I. Rockwood 260
Equalizer trouble, L. G.'s, By Ira M. Cushing 241
Exhaust, Head; Sims Co. 69
Expansion co-efficients for iron, steel and copper 65

F

Fahnestock Co.; New "Button" telephone transmitter 206
Fan blowers, Heating and ventilating by, By Chas. L. Hubbard 55
Feed-water heater; Anderson-McCutchen Co. 472
—— —— purifier *40
Filter, Oil; Scranton Oil Filter Co. 433
Fish arc lamp (patent) 549
—— multiple arc lamp (patent) 360
Fire extinguisher, A handy, By F. P. De Wilde 241
Flywheels, Centrifugal force in, (Edit.) 552
—— and flywheel accidents, By R. T. Strohm 536
Forbes grip nut *450
Ford Plate Glass Co.'s power plant, By J. R. Cravath 211

Formulas:

Commercial efficiency of a motor (Q. & A.) 160
Constant of a Siemens' dynamometer 104
Middle ordinate of a circular arc 104
Percentage of error in a wattmeter (Q. & A.) 429
Pulley diameters (Q. & A.) 568
Water required by a water wheel (Q. & A.) 377

Foster's stop valves *307
Foundry and pattern department of B. F. Sturtevant Co. 573
Francke, W. J.: Four-ported engine 168
Frequency, Alternating current, for transmission lines (Edit.) 414
Ft. Wayne Electric Works: Installation of modern lighting transformer 327
Fuel feeder and regulator; C. O. Bartlett & Snow Co. 71
——, Liquid, By H. F. Schmidt, 118; Chas. L. Hubbard 396
Furnace and boiler efficiencies, By A. Bement 351
Fuses (Lessons) 426
——, Enclosed; McBride Mfg. Co. 249
——, Peard *185

G

Galvanometer, Construction of a D'Arsonval mirror, By F. W. Cerny 94
Garton-Daniels Co.: Telephone extension circuit-closer 167
Gas engine auxiliary plants (Edit.) 146
—— —— exhaust muffler, A home-made, By E. S. Lincoln 62
—— —— plants. See Power plants.
Gauge-cock; P. B. Huyette 524
Gauge, Water *307
Gas engines. See engines, Gas
General Electric Co.: Air compressors for railway brakes, 323; Curtis steam turbine, 244; Lightning arresters, 432; Motors for New York subway, 209; Small plant switchboard, 243
General Incandescent Arc Light Co.: Enclosed arc lamp 326
General Power Co.: Secor standard oil engine. 207
General Specialty Co.: Boiler cleaner 471
Generating units, Belted *vs.* direct-conected, (Edit.) 508
Generator. See also Alternator and Dynamo.
——, The asynchronous, By A. S. M'Allister 534
——, Double current, at the Trafford power station *410
—— and motor, combined for automobiles (patent) 308
Generators, Mixed loads on three-phase, (Edit.) 363
Gest, C. M.: Cable bracket frame 432
Goodrich, B. F., Co.'s plant, Steam turbine installation at, 539
Governor, Automatic Pelton water-wheel, *546
—— drives for Corliss engines 413
—— New "Ball" engine; Ball Engine Co. 70
—— Robinson's shaft, *42
—— Woodward friction water-wheel; Woodward Governor Co. 105
Governors for internal-combustion engines *225
Grand Union Tea Company's power and lighting plant, Brooklyn, N. Y. 490
Grate-bar; Martin Grate Co. 571
Grip nut, Forbes, *450
Gutta-percha, Properties of, *356

H

Hamblin Co., John A.: Enclosed arc lamp 620
Hart & Hegeman Mfg. Co. Conduit fastener, 206; Cut-out and snap switch combined, 523; Electric heater switch, 111; Lock push switch 619
Harvesting by electric power, By Hamilton Wright 172
Heater, Feed-water. See Feed-water heater.
Heating and ventilating by forced blast, By Chas. L. Hubbard 55
Heyland induction motor, The, By A. S. M'Allister, 331; (Edit.) 362
Hewitt static converter 81
Holtzer-Cabot Electric Co.: Gas engine igniter, 249; "Hotelephone," 109; Telephone receiver 382
Hoppes Mfg. Co.: Oil eliminator 383
Hornsby-Akroyd oil engine; De La Vergne Refrigerating Machine Co. 326
Hot well as an oil extractor, The, By A. H. Eldredge 425
Hunt, C. W., Co.: Electric storage battery locomotive 325
Huyette, P. B.: Gauge-cock 524
Hydraulic plants. See Power plants.
Hylo automatic flash sign lamp; Phelps Co. 381
—— improved incandescent lamp; Phelps Co. 70

I

"Ideal" fuse switch, Linton & Southwick 524
Igniter, Ganz gas engine, (patent) 411
—— Gas engine; Holtzer-Cabot Electric Co. 249
Ignorance, Confidence of, (Edit.) 455
Improved Elec. Lt. & Supply Co.: Nernst lamp 618
Incandescent lamp, The, (Lessons) 200, 239
—— ——; Bryan-Marsh Co. 474
—— ——; Downward Light Electric Co. 572
—— ——, Howell high-voltage, (patent) 308
—— ——, Hylo automatic flash sign; Phelps Co. 381
—— ——, "Hylo" improved; Phelps Company 70
—— —— manufacture *594
—— ——, Miller; Missouri American Electric Co. 431
—— ——, Resistance required in series with, to produce a given candle-power, J. W. Langley chart; Wirt Electric Co. 327
—— ——, Sirius high-efficiency, *357
—— ——, "White Star"; Standard Electrical Mfg. Co. 524
—— ——, Zenith; New York and Ohio Company 432
—— —— fixture, Kinsman portable and desk; McLeod, Ward & Co. 535
Incandescent lamps, Non-platinum leading in wires for, *546
—— ——, The Manufacture of, *186
Indicator, An electric train, By E. G. Parham 154

Indicator cards, Freak, By C. E. Bibb 520
——— diagrams, By Chas. L. Hubbard ..513, 603
———, Maximum demand; Schattner Electricity Meter Co. 72
———, Power factor, ...*355
———, Pratt power factor, (patent) 411
———, Woodbridge synchronism, (patent).... 226
Inductance and impedance of telephone cable (Q. & A.) 568
Induction coil to give ½-inch spark, Data of, (Q. & A.) 65
——— ——— to give a 6-inch spark, Data of, (Q. & A.) 204
——— ———, Parcelle, (patent) 226
Induction coils, Operating, from lighting circuits, By Arthur Barthels 100
——— ———, Voltage ratio of, (Edit.) 553
Instruments, Direct-current measuring, (Lessons) 465
Insulating material for wooden bobbins (Q. & A.) 468
Insulator, Converse high-tension, (patent).... 452
Insulators, Choice of high-tension, By H. C. Knowlton 439
———, High-tension; Locke Insulator Mfg. Co. 71
———, Testing of, By F. O. Blackwell, 174; (Edit.) 188
International Telephone Mfg. Co.: Telephone transmitter and receiver.... Adv. March, 61
Interrupter, Renewable Wehnelt, ...*501
———, Nilson vibrating, (patent) 44
Isolated plant of the Bay City Industrial Works, Mich. 470
——— ——— of the Central Railroad of N. J. repair shops at Elizabethport, N. J., 436; (Edit.) 454
——— ——— of the Edward Ford Plate Glass Co., By J. R. Cravath 211
——— ——— of the B. F. Goodrich Co. ... 539
——— ——— of the Grand Union Tea Company, Brooklyn, N. Y. 491
——— ——— of the Keystone Bank Building, Pittsburg, Pa. 171
——— ——— of Landers, Frary & Clark, By W. G. Viall 329
——— ——— of the Macy store, New York, By Chas. E. Knox 73
——— ——— of the Orange Brewery, Orange, N. J. 469
——— ——— of the Prudential Insurance Company, Newark, N. J. 1
——— ——— of the Southern Pacific Terminal Co. at Galveston, Tex., By C. W. Whitney 476
——— ——— voltage (Edit.) 92
Isolated plants *vs.* central station service (Edit.) 311
——— ———, Conductor subways for, (Edit.) 454
——— ——— Generating equipment for, By Paul C. Percy, 480; (Edit.) 508

K

Keystone Bank Building power plant, Pittsburg, Pa. 171
Kilowatts, Ratio of, to horse-power, By Robert M. Lee 158
Kinsman incandescent lamp fixture, McLeod, Ward & Co. 525

L

Lambert-Schmidt Mfg. Co.: Telephone equipment of the Manhattan elevated railway 378
Lamp. See Arc lamp, Incandescent lamp and Nernst lamp.
Lamp holder for photometers, Shelby, By J. C. Fish 243
——— socket construction, Improved; Marshall-Sanders Co. 71
——— ———; New England Electric Mfg. Co. 473
——— ———, Norbitt porcelain; Crouse-Hinds Co. 112
Landers, Frary & Clark power plant, By W. G. Viall 329
Langley chart showing resistance required in series with an incandescent lamp to produce a given candle-power; Wirt Electric Co. 327
Larsen, C.: Cable painter 109
Lathe, "Star" screw-cutting; Seneca Falls Mfg. Co. 247

Lessons in Practical Electricity:
  Arc lamp regulating mechanisms 157
  Direct-current measuring instruments 465
  Eddy currents in armature core discs and pole faces 61
  The electric arc 100
  Electrical measurements and the wheatstone bridge 563
  The incandescent lamp 200, 239
  Induction and the Induction coil 608
  Losses in dynamos and motors 61
  The Nernst lamp 320
  Safety devices 426
  Switches 373
  The wattmeter 518
  The Wheatstone bridge 564
Lighting circuits, Problem in. See Problem.
Lightning-arresters; General Electric Co. ... 432
Lightning, A curious effect from, By Leo Dolkart 520
Link-Belt Engineering Co.: Newspaper conveyors 166
Linton & Southwick: "Ideal" fuse switch 524
Literature, Standard business, ... 361
Locke Insulator Mfg. Co.: High-tension insulator 71
Locomotive, Electric storage battery; C. W. Hunt Co. 323
Lombard Governor Co.: Electro-mechanical governor 109
Lowell Model Co.: Stationary gasoline engine 250
Lunkenheimer Co.: Mechanical oil cup 168

M

Machado & Roller: New combination ohmmeter 245
Machine tools, Measuring the power of, By Geo. E. Walsh 440
——— ———, Operation of, by individual electrical motors, By R. T. E. Lozier .. 12
Macy & Company's isolated plant, New York, By Chas. E. Knox 73
Magnetic pull on a dynamo armature (Q. & A.) 521
Manhattan elevated railway fiasco (Edit.).. 47
——— ——— ——— system leased 44
——— ——— ——— telephone equipment; Lambert-Schmidt Mfg. Co. 378
Manufacturers, Combination of German, ... 45
Marinette Iron Works Mfg. Co,: Walrath gas engine 110
Marshall-Sanders Co.: Improved lamp socket construction, 71; Push-button switch .. 110
Martin Grate Co.: Grate-bar 571
McBride Mfg. Co.: New enclosed fuse 249
McLeod, Ward & Co.: Portable and desk lamps 525
McKibbin Mfg. Co.: "Little Mac" switch 617
Measurement of power in alternating-current circuits, By N. R. Craighill 460
Measurements, Electrical, and the wheatstone bridge (Lessons) 563
Measuring instruments, Direct-current, (Lessons) 465
——— power in alternating-current circuits with three voltmeters 606
——— the power of machine tools, By Geo. E. Walsh 440
Mechanical Boiler Cleaner Co.: Garrigus boiler cleaner 169
Meriden (Conn.) central station 575
Meter control, Oxley multi-rate, (patent) 90
———, Hot water, for boiler testing. By John A. Drew 607
———, Incandescent lamp; Talmont Elec. Eng. Co. 472
———, Maximum demand; Schattner Electricity Meter Co. 72
——— torque and friction, By Lyman C. Reed 122
Mietz & Weiss kerosene engine driving Bullock generator 522
Miller incandescent lamp; Missouri American Electric Co. 431
Monocyclic distribution from three-phase system, By F. Hardie Jeannin 366
Motor construction, American practice in electric, 20; (Edit.) 46
——— -controlling devices, By Elmer E. Warner 315
——— ——— Railway, (Edit.) 509
——— The double commutator, (Edit.) 147
——— and dynamo troubles *502
Motor, Induction; Design for a ½ horse-power, self-starting, single-phase, 148; 1 h.p. do., 416; 2 h.p. do. 456
——— ———; Determination of characteristic curves, By A. S. M'Allister 15
——— ———, The Heyland, By A. S. M'Allister, 331; (Edit.) 362
——— ———; Stanley Electric Mfg. Co. 473
Motor-generator *vs.* the rotary converter (Edit.) 552
——— operation, A few points in, By Geo. W. Malcolm 60
———, Pieper alternating-current commutator, (patent) 187
——— service, Three-wire system for variable speed, By N. W. Storer 18
———, shunt-wound, Action of, when driven by a series-wound dynamo, By A. S. M'Allister 79
———, The single-phase, (Edit.) 598
——— speed regulation, By G. A. Sylvain ... 240
——— wiring, Direct-current, By P. C. Percy 57
Motors, alternating-current, Automatic cut-out for, By F. P. De Wilde 466
——— ——— ———, for variable speed, By W. I. Slichter 407
———, Electric, for centrifugal pumps and fans, By Aug. J. Bowie, Jr. 544
——— ———, driving machine tools, Tests of, By Miles F. Moore 369
——— ——— in shops (Edit.) 46
——— Fan, for 1903, 124; (Edit.) 146
——— Fly-wheel, to compensate fluctuations of load in power transmission plants.. 453
——— General Electric, for New York subway 209
——— and generator combined, for automobiles (patent) 308
——— Induction, Care of, in a large factory, By Arthur B. Weeks 99
——— ———, for elevators, By A. B. Weeks 318
——— ——— for multiple speed work.... 232
——— Operation of machine shops by individual, By R. T. E. Lozier 12
——— Performance of two-phase, By J. B. Seaman 202
——— series, Method for finding the efficiency of *548
———, Use of Electric, ... 413
———, Variable-speed, three-phase, ... 40
———, Westinghouse, for New York subway 207
Muffler, A home-made gas engine exhaust, By E. S. Lincoln 62
Municipal lighting plant agitation (Edit.), 188; (Edit.) 233
——— ——— ——— at Tallahassee, Fla., By L. A. Poole 447
——— ownership convention, 145; (Edit.).. 146

N

Nernst lamp, The, (Lessons) 320
Nernst lamp for direct and alternating-current circuits; Nernst Lamp Co. 571
——— ——— glower, Arno three-phase, (patent) 44
——— ———, Improved; Imp. Elec. Lt. & Supply Co. 618
——— ———, Improvements in the, ...*408
Nernst lamps, Electric conductivity of filaments of, ...*86
Ness automatic telephone system, By A. Dallam O'Brien 236
New England Electric Mfg. Co.: Key socket 473
New York and Ohio Co.: Zenith incandescent lamps 432
N. Y. Central R. R. electric and turbine equipment 597
Nomenclature, Technical, (Edit.) 599
North Chicago Machine Co.: Cylinder oil atomizer 246
Numbering machine; Bates Mch. Co. 618
Nut, Forbes grip, ...*450

O

Obituary:
  Arnold, Everton B. 210
  Bliss, E. W. ....Aug. Adv. 51
  Breitenstein, G. F. 386
  Card, Wm. Warren 250
  Chalmers, Thomas ....Aug. Adv. 51
  Clark, Frank V. 574
  Daniels, John C. ....Dec. Adv. 55
  Herrick, J. Hobart 210
  Hesse, J. A. ....Aug. Adv. 51
  Lawton, Lyman T. 250
  Nixon, James Oscar ....Feb. Adv. 58
  Olmstead, F. D. 574
  Reilly, James 250
  Smith, S. Morgan 250
  Stauffer, John Forney 328
  Stieringer, Luther ....Aug. Adv. 51
  Thurston, Dr. R. H. ....Nov. Adv. 55
  Tyler, Wm. Perkins ....Feb. Adv. 58
  Wall, Francis Henry ....Feb. Adv. 58
  Werner, Paul 386
Ohmmeter, New Combination; Machado & Roller 245
Oil and boiler compound feeders, By Jas. F. Hobart 95
——— atomizer, Cylinder; North Chicago Machine Co. 246
——— cup, Lukenheimer mechanical, ... 168
——— eliminator; Hoppes Mfg Co. 383
——— pump. See Pump, Oil.
Oiling system for power plants, By P. E. Moock 235
Orange brewery, Mechanical equipment of, .. 469
Ordinate of a circular arc, Formula for finding the middle, ... 104
Ore finding system, An electrical, ...*223
Osborn-Morgan Co.: An interchangeable arc lamp 206
Oxidizing brass or copper (Q. & A.) 468

P

Peerless Automatic Smokeless Stoker Co.: Automatic stoker 108
Peiffer, P.: Kraushaar's universal duster 326
Pendant fixtures, Norbitt; Crouse-Hinds Co... 112
Pennsylvania terminal station, Steam turbines for, ... 506
Phelps Co.: Hylo automatic flash sign lamps, 381; Improved Hylo lamp 70
Pig-tailing a carbon brush (Q. & A.) 429
Pipe coverings, By R. T. Strohm 221
Piping, High pressure steam, By William Andrews 17
——— in modern power plant practice, By Chas. W. Oliver 262
Porcelain lamp socket, Norbitt; Crouse-Hinds Co. 112
Power production and distribution for large city street railway systems, By Richard McCulloch, 484; (Edit.) 509
——— plant, Bay City Industrial Works 470
——— ——— of the Berkshire Street Railway Co., Pittsfield, Mass. 387
——— ——— of the Central Railroad of N. J. repair shops at Elizabethport, N. J., 436; (Edit.) 454
——— ——— of the Edward Ford Plate Glass Co., By J. R. Cravath 211
——— ——— of the Keystone Bank Building, Pittsburg, Pa. 171
——— ——— of Landers, Frary & Clark, By W. G. Viall 329
——— ———: Mechanical equipment of the Orange Brewery, Orange, N. J. 469
——— ——— of the Mexican Central Railway Shops 616
——— ——— of the Southern Pacific Terminal Company at Galveston, Tex., By C. W. Whitney 476
——— ———, Swiss combined water-power and gas-engine, ... 113
——— service, Relative advantages of electrical and mechanical methods of variable speed control for, By Wm. Cooper, 337; (Edit.) 362
——— and telephone wires, Transposition and relative location of, By P. M. Lincoln .. 173

Pressure, Wind, on a circular chimney (Q. & A.) 204
Prime movers for central stations (Edit.)... 598
Problem in alternating-current operation, Mr. Benjamin's, By Wm. F. Dean 63
—— in bell wiring, By Charles W. Petry, 520; A. A. Isbell, 566, 610; John J. Marshall, Geo. W. Malcolm 567
—— —— ——. By Martin Smith ... 610
—— in lighting circuits, Mr. Lohman's, By Geo. A. Burnham, Fred Krebs, 101; Geo. W. Malcolm, Chas. Morrison and J. M. Tibbals, 102; C. H. Pool ..102, 159
—— in switch arrangement, Mr. Merrick's, By C. H. Pool, H. N. Snyder, John H. Marshall, 376; G. H. Merrick, 428; C. H. Pool, John J. Marshall 467
—— in telephone connections, Mr. Fisk's, By W. E. Stiefel, 62; Wm. A. Loveland, 62; Edwin R. Fisk 63
—— —— —— ——, Chas. H. Temple's, 202; By Glen Baskerville, L. S. Jenkins, Robert Kremer, 321; Geo. W. Malcolm 375
Prudential Insurance Company's power plant, Newark, N. J. 1
Pump, Aldrich horizontal quintuple; Allentown Rolling Mills 382
—— New automatic electric; Automatic Elec. Pump Co. 249
——, Oil; Sterrell Pump Co. 70
Pumping, Central station, at Grinnell, Ia... 413
——, City, from central stations, 231; (Edit.) 232
Pumps, Double acting boiler feed, ... *440
——, Driving boiler feed, By C. R. James, 81; (Edit.) 92
——, Electricaly driven, (Edit.) 310
Pupin's system, Application of, to telephone circuits *142
Purifier, Feed-water. See Feed-Water Purifier.

Q

Queen & Co.: Calculator for testing wattmeters 383

R

Railroads, Automatic block signals for, By Ralph Scott, 440; (Correction) 512
Railway, Alternating-current, high-tension installation of Berkshire Street Railway Co. 387
—— brakes, Air compressors for; General Electric Co. 323
—— car control, Automatic, ... *450
—— —— —— system, Electro-pneumatic; Westinghouse Co. 106
—— —— lighting; Axle system, By W. L. Bliss, 180; (Edit.) 189
—— feeder problems, Notes on, By Wm. A. Del Mar 371
——: High-speed experiments on Marienfeldt-Zossen line 461, 506, 551
——; Long electric line in Central Missouri 144
——; Manhattan elevated fiasco (Edit.) ..47, 93
——; —— —— system leased 44
—— motor construction (Edit.) 509
—— —— control system of N. Y. subway 205
—— Suspended, for Berlin 99
—— third-rail, Danger from, (Edit.) 455
—— train indicator, An electric, By E. C. Parham 154
—— —— safety device, Electric, By E. C. Parham 365
—— trolley wheels and stands, Care of, By Frank Berry, Jr. 194
Railways, Precautions against dangers on underground, (Edit.) 454
——, Reducing the noise on elevated, ... 399
Receptacle, Flush; Trumbull Elec Mfg. Co. 617
Receptacle, Permanent conduit and sign; Crouse-Hinds Electric Co. 72
Records and returns of central stations *449
Regulation of long-distance transmission lines. *450
Regulator, Chesney and Lloyd alternating-current circuit, (patent) 412
—— for steam engine driven dynamos, Brown, (patent) 186
Rheostat, Cast grid; Stanley Electric Mfg. Co. 380
——, Graphite, ... *594
——, New field; Cutler-Hammer Mfg. Co. .. 572
——, Water, for reversing motors *593
——; Wilson dynamo field, (patent) 593
Rheostats for dynamo load tests 549
Robb-Mumford Boiler Co.: Boiler 512
Roche, Wm. A.: Dry battery tests, 112; Spark plug 247
Rotary Engine Co.: Warren rotary engine 384
Ruger, J. W. Mfg. Co.: Gas engine 570
522

S

Safety device, Ferranti, ... *224
—— devices (Lessons) 426
—— devices, Electric, for low potential current installations *451
Safety-stop, Monarch motor; Consolidated Engine Stop Co. 326
Safety-valve area 17
—— —— and reducing valve, Combined, *357
Sal-ammoniac tests *307
Sangamo Electric Co.: Testing sets for alternating-current wattmeters 523
Schattner Electricity Meter Co.: Maximum demand indicator 72
Scranton Oil Filter Co.: Oil filter 433
Screw-threads, Cutting left-hand, with right-hand tools, By S. X. Callahan 467
Secor standard oil engine; General Power Co. 207
Seneca Falls Mfg. Co.: "Star" screw-cutting engine lathe 247
Separators, Internal, for steam boilers, By R. T. Strohm 393
Shelby Electric Co.: Lamp holder for photometers 243
Shock, The action of electrical, ... *306
—— due to playing a stream of water against an electric conductor *450
——, Electric, ... *502
Shops, Use of individual motors in, By R. T. E. Lozier 12
Signal system for street railways, Automatic block; Uni Signal Co. 612
Signals, Automatic block, for railroads, By Ralph Scott, 441; (Correction) 512
Signs, Electrical display, By Geo. Rice 334
Sims Company: Exhaust head 69
Sirius high efficiency incandescent lamp.... *357
Smith & Hemenway Co.: Linemen's climbers 169
Smith Storage Battery Co.: Storage battery installation, Hotel Carlton, Boston 327
Solder, Recipes for soft, ... 340
Southern Pacific Terminal Company's power plant at Galveston, Tex., By C. W. Whitney 476
Spark length for X-ray tubes (Q. & A.) 242
—— plug; William Roche 384
St. Louis Exposition, Electrical exhibits at,.. 550
Stamp, Time, for telephone switchboard, Automatic; Automatic Time Stamp Co. 246
Standard Electrical Mfg. Co.: White Star incandescent lamp 524
Stanley Electric Mfg. Co.: Cast grid rheostats, 380; S. K. C. circuit breaker, 324; Induction motor, 473; Revolving-field alternators, 107; Voltmeter compensator .. 430
Stanley Instrument Co.: Glass enclosed wattmeter 381
Static electricity, A question in, By Louis T. Andre, 520; J. T. Smith 566
Steam boiler, condenser, engine, pipes, pump, separator, trap, etc. See Boiler, Condenser, Engine, Pipes, Pump, Separator, Trap, etc.
Steam, Density of superheated and saturated (Q. & A.) 521
—— plant auxiliaries, By Henry C. Meyer, Jr. 261
—— practice in central stations (Edit.).. 310
——, Superheated, By E. H. Foster 11
Steel, Electric manufacture of, By Geo. E. Walsh 123
Sterrett Pump Co.: Oil pump 70
Stevenson, John, Co.: Portable motor-driven air compressors 381
Stoker, Automatic; Peerless Co. 108
—— ——; C. O. Bartlett & Snow Co. .. 71
Stromberg-Carlson Telephone Mfg. Co.: Hook-switch, 69; Telephone ringer 110
Stuffing-boxes without packing *408
Sturtevant, B. F., Co.: The new foundry and pattern department 573
Sulphur dioxide vapor, Properties of, ... 597
Sudgen water-tube boiler *88
Superheated steam, Tests of a Belgian engine using, 217; (Edit.) 233
—— ——, Tests of an English engine using, ... 178
Swan Electric Mfg. Co.: Electrotonic battery 111
Switch connections, Pole changing, By E. S. Lincoln 240
——, Electric heater; Hart and Hegeman Mfg. Co. 111
——, knife, Newlett and Baden laminated ever, (patent) 360
——, Liquid resistance *593
——, Lock push; Hart & Hegeman Mfg. Co. 619
——, Push-button; Marshall-Sanders Co... 110
——, Snap and cut-out combined; Hart & Hegeman Mfg. Co. 523
——, Swoboda knife, (patent) 452
——, Strap; G. N. McKibbin Mfg. Co. 617
Switchboard, Hewlett arc light, (patent) ... 143
Switchboards, Small plant; General Electric Co. 243
Switches (Lessons) 373
——, Babcock motor starting, (patent) .. 504
——, High-tension oil, ... *501
—— "Ideal" fuse; Linton & Southwick ... 524
——, Problem in, See Problem.
Swoboda knife switch (patent) 452
Synchronizer. See Synchronism indicator.

T

TABLES:
Prony brake 84, 85, 192
Current densities in standard wires 526
Wiring 97, 98
Tallahasse, Fla. The municipal lighting plant at, By L. A. Poole 447
Talmont Electric Engineering Co.: Incandescent lamp meter 473
Technical nomenclature (Edit.) 599
Telegraph lines, Erecting, under difficulties.. 562
——, Wireless. See Wireless Telegraph.
Telephone branch exchange, A common battery private, By A. Dallam O'Brien... 566
—— —— ——, Douglas, in Chicago ... 586
—— circuits, Application of Pupin's system to *142
—— ——, Problem in, See Problem.
—— engineering, By F. J. Dommerque. Preservation of timber, 80; Treatment of poles, 120; Wire, 213; Erecting poles, 335; Stringing out-door wires, 394; Cables, 448; Cable tests and specifications, 488; Aerial Cable Lines 542
—— equipment of the Manhattan elevated railway; Lambert-Schmidt Mfg. Co.... 378
—— exchange, A modern private branch, By A. Dallam O'Brien 150
—— ——, Magneto switchboard for a small, By A. Dallam O'Brien 604
—— extension circuit closer; Garton-Daniels Co. 167
—— hook-switch; Stromberg-Carlson Tel. Mfg. Co. 69
——, Magneto; Vought-Berger Co. 523
—— and power wires, Transposition and relative location of, By P. M. Lincoln 173
—— receiver; Holtzer-Cabot Electric Co. .. 382
—— repeater, Sundquist, (patent) 596
—— ringer; Stromberg-Carlson Mfg. Co. .. 110
—— set, "Hotelephone"; Holtzer-Cabot Electric Co. 109
—— system, Automatic, By A. Dallam O'Brien 236
—— ——, Automatic; Automatic Electric Co. 161
—— ——, Central intercommunicating, By H. S. Webb 602
—— ——, Central energy multiple, By E. T. Evans 197
—— ——, Monoplex intercommunicating; Atwater-Kent Mfg. Co. 111
—— ——, Seely and Hemsing intercommunicating, (patent) 595
—— ——, Sloper and Parsons intercommunicating, (patent) 90
—— ——, A small common battery, By Chas. H. Coar 610
—— systems, Common battery, By Chas. J. Sutter 159
—— ——, Intercommunicating, By A. Dallam O'Brien 316, 367, 418
—— ——, Two-wire intercommunicating, H. S. Webb 515
—— transmitter, New "Button"; The Fahnestock Co. 206
—— —— and receiver; International Telephone Mfg. Co. ....Mar. Adv. 61
Telephones, Iron box; Couch & Seeley Co. .. 524
Terminals and binding posts, Common sense, By Elmer E. Warner 315
Test board, a convenient, By Arthur Barthels 100
—— for core loss of a dynamo (Q. & A.) .. 468
Testing apparatus, Lewis' electrical, (patent). 308
—— of insulators, By F. O. Blackwell, 174; (Edit.) 188
—— power plant machinery (Edit.) 233
—— set for alternating-current wattmeters; Sangamo Electric Co. 523
—— set, A home-made, By Frank W. Cerny 201
Tests of a Belgian engine using superheated steam, 217; (Edit.) 233
—— of boilers and engines of Meriden (Conn.) station 581
—— Dry battery; Wm. A. Roche 112
——of an English engine using superheated steam 178
—— of motors driving machine tools, By Miles F. Moore 369
—— Sal-ammoniac, ... *307
Third rail, Danger from, (Edit.) 455
Thunder storms, Electrical disturbances during, By Frank W. Cerny, 241; T. N. Slocum 376
Timber-treating process, New, ... 183
Tin from scrap, Electrolytic recovery of *88
Tools, Cutting left-hand screw-threads with right-hand, By S. N. Callahan 467
Transformer, Construction of a small variable voltage, By W. B. Roberts 554
——, Hull constant current, (patent) 504
——, Installation of a modern lighting; Ft. Wayne Electric Works 327
——, New type of, ... *547
——, Regulating, for long distance transmission lines *450
—— regulation (Edit.) 455
Transformers on different frequencies (Edit.) 311
Transmission, Composite electrical, (Edit.) .. 189
—— lines, Arrangement and control of long distance, ... *450
—— lines, Capacity of, (Edit.) 454
——, Some difficulties of long distance electric, By Paul M. Lincoln 212
Trap, steam, Simple expansion, ... *224
—— ——, Compound expansion, ... *356
—— ——, Victor low-pressure; Wright Mfg. Co. 431
Trolley, Terry current-collecting, (patent) .. 227
—— wheels and stands, Care of, By Frank Berry, Jr. 194
—— wire sizes ordinarily used (Q. & A.) . 377
Trumbull Elec. Mfg. Co.: Flush receptacle... 617
Turbine, Steam, Curtis; General Electric Co. 244
—— ——, efficiency, By W. T. Edwards 255
—— ——, installation in B. F. Goodrich Co.'s plant, Akron, O. 539
Turbines, Steam, for the Pennsylvania terminal station 506

V

Valve, Electrohydraulic; Engberg Electric & Mechanical Works 431
——, Safety. See Safety-Valve.
Valves, Foster's stop, ... *307
Varnish for copper (Q. & A.) 429
Ventilating and heating by forced blast, By Chas. L. Hubbard 55
Victor low-pressure steam trap; Wright Mfg. Co. 431
Voltage, Dangerous rises in, due to resonance. *305
Vought-Berger Co.: New magneto telephone .. 523

W

Warren rotary engine; Rotary Engine Co. .. 570
Water gauge. See Gauge, Water.
——— powers, Development of small, By Louis Bell 582
——— required by a water wheel (Q. & A.) 377
Wattmeter, The, (Lessons) 518
———, Calculating the percentage of error in a, (Q. & A.) 429
——— connections, Integrating, By Arthur B. Weeks 156
———, Glass enclosed; Stanley Instrument Co. 381
Wattmeters, Calculator for testing; Queen & Co. 383
———, Direct current; Duncan Electric Mfg. Co. 167
Welding by the aluminothermic process 591
Westinghouse Electric & Mfg. Co.: Electro-pneumatic railway control system, 106; Long scale alternating-current ammeter, 245; Motors for New York subway, 207; Oil circuit breaker for high-tension circuits 169
Westinghouse Machine Co.: New gas engine. 163
Wheatstone bridge, Electrical measurements and the, (Lessons) 563
White Star incandescent lamp; Standard ... Electrical Mfg. Co. 524
Wilson dynamo field rheostat (patent) 549
Wind-mill drive for electric plants ...519, *549
Wire joint, Aluminum, ... 80
——— transposition, Line, ... 68
Wireless telegraph coherer, A simple, By F. W. Cerny 62
——— ——— outfit; Thos. E. Clark Wireless Tel.-Tel. Co. 383
——— telegraphy, Transatlantic, 44, (Edit.) 599
Wires, Breaking of loop, ... 344
Wiring, Alternating current, By Cecil P. Poole 421
———, Bell, Problem in, See Problem.
———, Direct current motor, By P. C. Percy 57
——— inspection, Inadequate, (Edit.) 553
——— Three-wire direct-current, By P. C. Percy 97
———, Underground, for towns 364
Wirt Electric Co.: Langley chart showing resistance required in series with an incandescent lamp to produce a given candle-power 327
Wood, New method for preserving, ... 538
Woodward Governor Co.; Friction water-wheel governor 105
Woolley Fdry. & Mch. Wks.: Burger automatic gas engine 569
Worthington Company's new works 616
Wright Mfg. Co.: Victor low-pressure steam trap 431

Z

Zenith incandescent lamps; New York and Ohio Co. 432

AUTHOR INDEX.

Andre, Louis T. A question in static electricity 520
Andrews, William. High pressure steam piping 17

Barrus, Geo. H. Some points regarding boiler practice in electric light and power stations 256
Barthels, Arthur. Operating induction coils from lighting circuits—A convenient test board 100
Baskerville, Glen. Mr. Temple's problem in telephone circuits 321
Bell, Louis. Development of small water powers 582
Berry, Frank, Jr. Care of trolley wheels and stands 194
Bibb, C. E. Freak indicator cards 520
Blackwell, F. O. The testing of insulators.. 174
Bliss, W. L. An electric car lighting system 180
Bowie, Aug. J., Jr. Electric motors for centrifugal pumps and fans 544
Brocksmith, J. C. Design for an electric runabout 48
——— Construction of a magnetic vane voltmeter or ammeter 600
Brown, Walter. Improved commutator construction 428
Burnham, Geo. A. Mr. Lohman's problem in lighting circuits 101
Bury, W. S. Testing the polarity of battery connections without a polarized voltmeter 520

Callahan, S. X. Cutting left-hand threads with right-hand tools 467
Cerny, F. W. Construction of a D'Arsonval mirror galvanometer 94
——— Electrical disturbances during thunder storms 241
——— A home-made testing set 201
——— A simple wireless telegraph coherer.. 62
Charles, H. B. Unusual dynamo performance 101
Coar, Chas. H. A small common battery exchange 610
Cooper, William. Relative advantages of electrical and mechanical methods of variable speed control for general power service 337
Cort, J. J. Relation between effective and mean values of currents or electromotive forces 370
Craighill, Nathaniel R. Design for a 15-horsepower brake dynomometer 190
——— Measurement of power in alternating current circuits *460
Cravath, J. R. Central station at De Kalb, Ill. 251
——— Isolated plant of the Edward Ford Plate Glass Co. 211
Cushing, Ira M. L. G.'s equalizer trouble.... 241

Dean, Wm. F. Mr. Benjamin's problem in alternating current operation 63
Del Mar, Wm. A. Notes on railway feeder problems 371
De Wilde, F. P. Automatic cut-out for alternating-current motors 466
——— A handy fire extinguisher 241
Doane, Francis H. A convenient repair shop floor crane 364
Dolkart, Leo. A curious effect from lightning 520
Dommerque, F. J. Telephone engineering 80, 120, 213, 335, 394, 448, 488, 542

Edwards, W. T. The boiler blow-off 425
——— Steam turbine efficiency 255
Eldredge, A. H. The hot-well as an oil extractor 425
Evans, E. T. A central energy multiple telephone system 197

Fernandez, W. T. Operation of rotary converters 458
——— Parallel running of alternators 155
Fisk, Edwin R. A problem in telephone connections 63
Foster, E. H. Superheated steam 11
Fowler, Clarence P. Some notes on the hunting of rotary converters 556

Guilbert, John. Mr. Temple's telephone connection problem 375

Hallberg, J. Henry. The application of 4-ampere series alternating enclosed arc lamps to city lighting 369
Hobart, Jas. F. Oil and compound feeders for boilers 95
Hubbard, Chas. L. Boiler accessories 194
——— Boiler settings 557
——— Heating and ventilating by forced blast 55
——— Indicator diagrams 513, 603
——— Liquid fuel 397
——— Mechanical draft 215

Isbell, A. A. Mr. Petry's problem in bell connections 566, 610

Jackson, Roy C. Arc lamp construction 565
James, C. R. Driving boiler feed pumps.... 81
James, H. D. Electric control for elevators 83
Jeannin, F. Hardie. Monocyclic current from three phase system 366
——— New method of obtaining constant current 412
——— Parallel operation of alternators 517
Jenkins, L. S. Mr. Temple's problem in telephone circuits 321

Kintner, S. M. A simple form of circuit-breaker 234
Knox, Chas. E. The electrical equipment of the new Macy store building 73
Knowlton, H. C. The choice of high tension insulators 439
——— An oil engine central station 404
Krebs, Fred. Mr. Lohman's problem in lighting circuits 101
Kremer, Robert. Mr. Temple's problem in telephone circuits 321

Lee, Robert M. Ratio of kilowatts to horsepower 158
Lincoln, E. S. A home-made gas engine exhaust muffler 62
——— Pole changing switch connection 240
Lincoln, Paul M. Some difficulties of long distance electric transmission 212
——— Transposition and relative location of power and telephone wires 173
Liversidge, H. P. Practical storage battery operation 462
Loveland, William A. Mr. Fisk's problem in telephone connections 62
Lozier, R. T. E. The operation of machine shops by individual electric motors.. 12

M'Allister, A. S. Action of a shunt-wound motor when driven by a series-wound dynamo 79
——— Asynchronous generators 534
——— Circuits for the transmission and distribution of electrical energy 175
——— Determination of induction motor characteristic curves 15
——— The Heyland induction motor 331
McBride, Daniel B. Some points in arc lamp operation 428
M'Culloch, Richard. The production and distribution of alternating current for large city street railway systems 484
McDermott, Frank A. Electrodeposition of aluminum from aqueous solutions 565
Malcolm, Geo. W. A few points in motor operation 60
——— Mr. Lohman's problem in lighting circuits 102
——— Mr. Petry's problem in bell connections 567
——— Mr. Temple's telephone connection problem 375
Marshall, John J. Mr. Merrick's question of switches 376, 467
——— Mr. Petry's problem in bell connections 567
Merrick, G. H. Problem in switches 428
Meyer, Henry C., Jr. Steam plant auxiliaries 261
Moock, P. E. Oiling system for power plants 235
Moore, Miles F. Tests of motors driving machine tools 369
Morrison, Charles. Mr. Lohman's problem in lighting circuits 102
O'Brien, A. Dallam. Automatic telephone system 236
——— A common battery private branch exchange 560
——— Intercommunicating telephone systems 316, 367, 418
——— A magneto switchboard for small telephone exchanges 604
——— A modern private branch telephone exchange 150
O'Hanlon, F. B. A simple alternating current booster 481
Oliver, Chas. W. Steam piping in modern power plant practice 262

Parkham, E. C. An electric train indicator.. 154
——— Electric train safety device 365
——— Failure of direct-current dynamos to generate 238
Parrish, Junior. Single-phase 60-cycle alternators in parallel 321
Percy, P. C. Direct current motor wiring .. 57
——— Generating equipment for isolated plants 480
——— Three-wire direct-current wiring 97
Petry, Charles W. A problem in bell wiring 520
Pool, C. H. Mr. Lohman's problem in lighting circuits 102, 159
——— Mr. Merrick's problem in switches, 376, 467
Poole, Cecil P. Alternating current wiring.. 421
——— Design for 150-ampere electroplating dynamo 312
Poole, L. A. The municipal lighting plant at Tallahassee, Fla. 447

Reed, Lyman C. American meter practice .. 122
Rice, George. Electrical display signs 334
Richards, Joseph W. Electrodeposition of aluminum from aqueous solutions 565
Roberts, W. B. Construction of a small variable voltage transformer 554
Rockwood, George I. Steam engines for electric power stations 260
Rutherford, C. N. Belt action on pulleys out of line 202

Schmidt, H. F. American steam engines for electric light and power service 267
——— Liquid fuel 118
Scott, Ralph. Automatic block signals for railroads 441
——— Some hints on the care and paralleling of direct-current dynamos 193
Seaman, J. B. Performance of two-phase motors 202
Slichter, W. I. Alternating current motors for variable speed 407
Slocum, T. N. Mr. Cerny's experience with atmospheric electricity 376
Smith, James T. Static charge on safety valve 566
Smith, Martin. Problem in bell connections.. 610
Snyder, H. N. Mr. Merrick's problem in switches 376
Stiefel, W. E. Mr. Fisk's problem in telephone connections 62
Strohm, R. T. Flywheels and flywheel accidents 536
——— Internal separators for steam boilers. 393
——— Pipe coverings 221
Sutter, Chas. J. Common battery telephone systems 159
Sylvain, G. A. Motor speed regulation 240

Temple, C. H. A telephone connection problem 202
Tibbals, J. M. Mr. Lohman's problem in lighting circuits 102

Viall, W. G. The lighting and power plant of Landers, Frary and Clark 329

Walsh, George E. Electric haulage on French canals 266
——— Electric manufacture of steel 123
out of line 240
——— Common sense terminals and binding posts 315
Webb, H. S. Two-wire intercommunicating telephone systems 515
——— A central energy intercommunicating telephone system 602
Weeks, Arthur B. The care of induction motors in a large factory 99
——— Induction motors for elevators 318
——— Integrating wattmeter connections ... 156
Whitney, C. W. Power plant of the Southern Pacific Terminal Company at Galveston, Tex. By C. W. Whitney 476
Wilson, B. C. Alternator regulation 158
Wright, Hamilton. Harvesting by electric power 172

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